

Introduction to Bioinorganic Chemistry

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BIOC 301

What is biological inorganic chemistry (bioinorganic chemistry)?

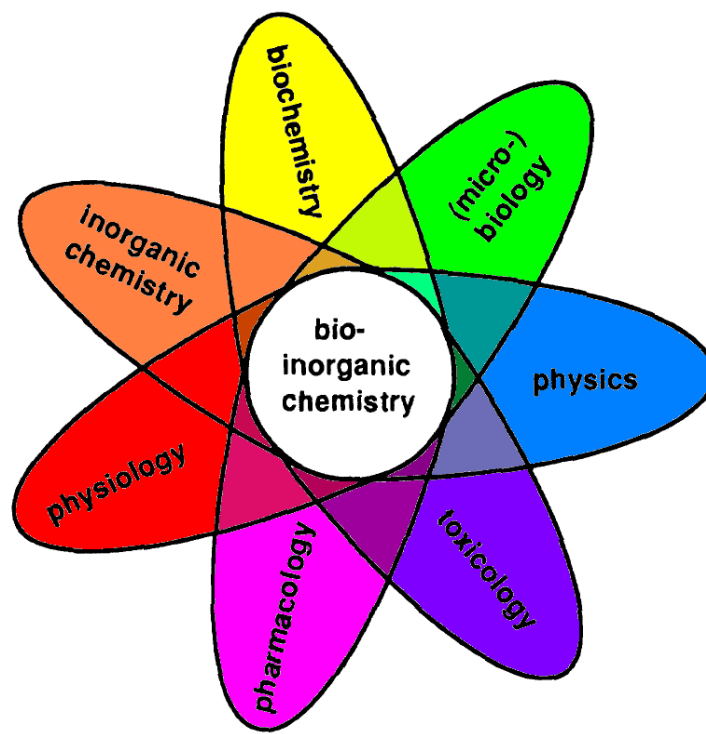
- An interdisciplinary research field at the interface of the more classical areas of inorganic chemistry and biology/biochemistry.
- Understanding the roles that metallic and non-metallic elements play in biological systems is the goal of biological inorganic (bioinorganic) chemistry.

What is biological inorganic chemistry (bioinorganic chemistry)?

There are two main fields of bioinorganic chemistry:

- 1. Investigations of inorganic elements in processes e.g. nutrition, the toxicity of inorganic species, including the ways in which such toxicities are overcome both by natural systems and by human intervention, and of metal-ion transport and storage in biology.
- 2. The introduction of metals (metal complexes) into biological systems as probes and drugs

An Interdisciplinary Research Field



Kaim, W.; Schwederski, B. *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life*, Wiley, New York, **2013**.

Occurrence and availability of inorganic elements in organisms

- The familiar elements **C, H, N, O, P and S**, the big six, which are well covered in biochemistry texts provide the major building blocks for cellular components including proteins, nucleic acids, lipids-membranes, polysaccharides and metabolites.
- Despite this organic diversity, **life cannot survive** with only these principle elements.

Occurrence and availability of inorganic elements in organisms

- Inorganic elements are also essential to life processes - eleven elements of the periodic table are required for all forms of life and an additional seven or eight elements are used by organisms on our planet.
- Blood known to contain iron since the 17th century.
- Need for Zinc, 1896.

Essential and Non-Essential Elements

- ▶ Essential elements are those elements which **are required for the maintenance of life**
- ▶ Absence of these elements results in death or a severe malfunction of the organism
- ▶ Example: oxygen, hydrogen, nitrogen, calcium, phosphorous
- ▶ Non-essential elements are those elements which **don't play any positive role in biological systems**
- ▶ Absence of these elements does not affect the body of an organism
- ▶ Example: Aluminium (Al), Strontium (Sr), Barium (Ba), Tin (Sn) etc

Essential Elements

Bulk Elements

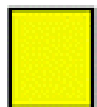
Trace Elements

Bulk elements: They are the elements which are found in higher concentrations. Examples: O, C, H, N, P, Na, K, Mg, Cl, Ca, S etc.

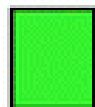
Trace elements: They are those elements which are needed in very low concentrations. Examples: Fe, Cu, Zn, Mn, Co, Mo etc.

Elements Essential for Life in the Periodic Table

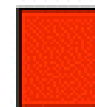
1 H 1.0079 Hydrogen																	2 He 4.0026 Helium
3 Li 6.941 Lithium	4 Be 9.0122 Beryllium											5 B 10.811 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluorine	10 Ne 20.180 Neon
11 Na 22.990 Sodium	12 Mg 24.305 Magnesium											13 Al 26.982 Aluminum	14 Si 28.086 Silicon	15 P 30.974 Phosphorus	16 S 32.065 Sulfur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
19 K 39.098 Potassium	20 Ca 40.078 Calcium	21 Sc 44.956 Scandium	22 Ti 47.867 Titanium	23 V 50.942 Vanadium	24 Cr 51.996 Chromium	25 Mn 54.938 Manganese	26 Fe 55.845 Iron	27 Co 58.933 Cobalt	28 Ni 58.693 Nickel	29 Cu 63.546 Copper	30 Zn 65.38 Zinc	31 Ga 69.723 Gallium	32 Ge 72.630 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon
55 Cs 132.91 Cesium	56 Ba 137.33 Barium	57-71 La-Lu	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 209 Polonium	85 At 210 Astatine	86 Rn 222 Radon
87 Fr 223 Francium	88 Ra 226 Radium	89 Ac 227 Actinide	90 Th 232.04 Thorium	91 Pa 231.04 Protactinium	92 U 238.03 Uranium												



Bulk biological elements



Trace elements believed to be essential for bacteria, plants or animals

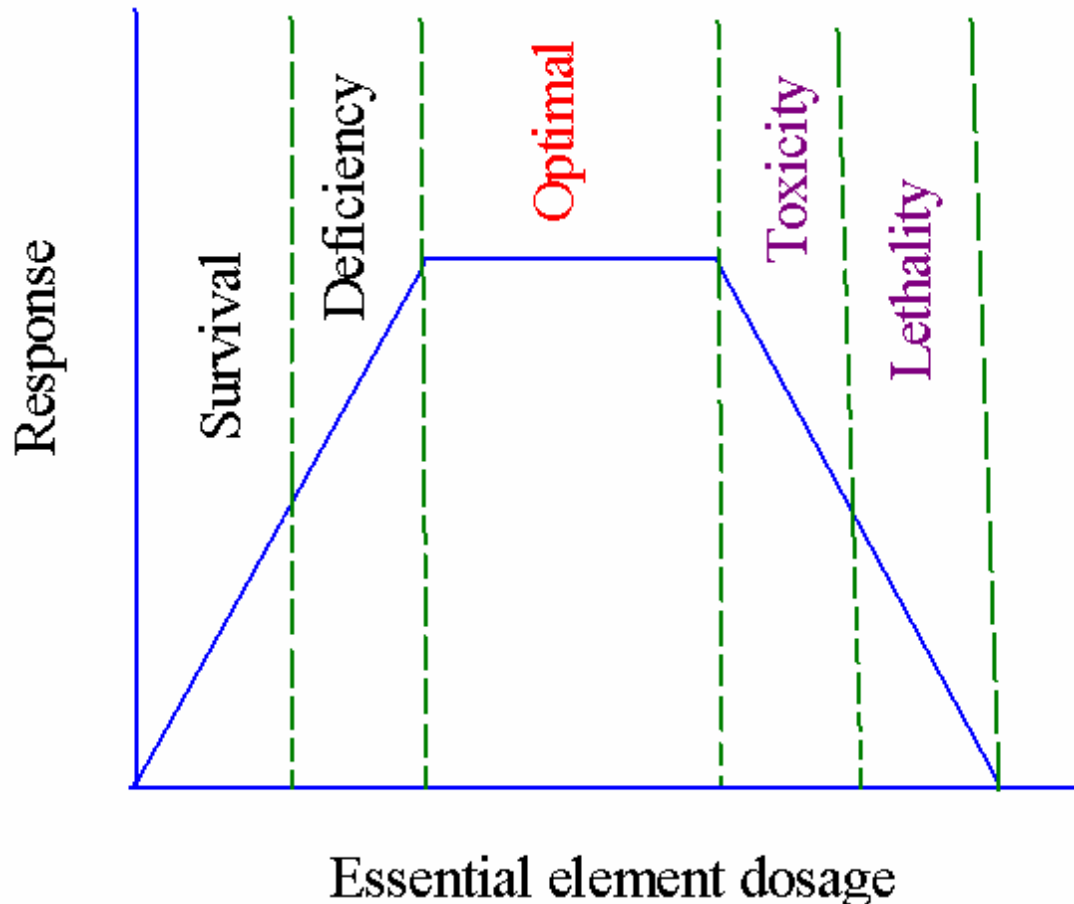


Possibly essential trace elements for some species

Essentiality of elements is defined by

- A physiological deficiency appears when the element is removed from the diet
- The deficiency is relieved by the addition of that element to the diet
- A specific biological function is associated with the element

Every essential element follows a dose-response curve



Explanation of dose-response curve

- At lowest dosages organism does not survive
- In deficiency regions, the organism exists with less than optimal functions
- After optimal dosage (plateau region), higher dosage cause toxic effects in the organism eventually leading to lethality