

Advances in the molecular understanding of biological zinc transport

Claudia A. Blindauer

Electronic Supplementary Information

Table S1: Important families of membrane-bound metal transporters with zinc-transporting members.

Table S2: Examples of proteins involved in intracellular (including periplasmic) zinc binding.

Table S1. Important families of membrane-bound metal transporters with zinc-transporting members. Other metals that have also been shown to be transported by members of these families are also listed. The column “direction” is with reference to the cytosol. The given locations are non-exhaustive. Abbreviations: PM: plasma membrane, OM: Outer membrane, IMM: Inner mitochondrial membrane; V: vacuole membrane; G: Golgi apparatus membrane; PMF: proton-motive force.

Family	TC super-family	Other metal ions	Organisms	Direction	Location	Driving force	Examples	Regulated by	Remarks
CorA/MIT	1.A.35	Mg ²⁺	Enterobacteria	Efflux	PM	unclear	ZntB (<i>S. Typhimurium</i> , <i>V. parahaemolyticus</i>)	?	pdb: 3nwi See Fig.7
TonB dependent receptors	1.B.14	Fe ³⁺ chelates	Bacteria	Uptake	OM	requires energy from TonB-ExbB-ExbD complex	Alr3242 (<i>Anabaena PCC7120</i>) AB57_3396 (<i>Acinetobacter baumannii</i>) PA0781 (<i>P. aeruginosa</i>)	Zur Zur	
β-barrel porins	1.B.23 1.B.25	any	Bacteria, plastids, mitochondria	Uptake/efflux	OM	Concentration gradient?	OprD (<i>P. aeruginosa</i>) SomB (<i>Syn. PCC7942</i>)	Zur Zur	
CDF	2.A.4	Fe, Co, Zn, Ni, Cu, (Cd, Hg) (all 2 ⁺)	Any	Efflux	PM, V, G, and many others	PMF and Me ²⁺ :H ⁺ antiport	ZnT (animals) MTP (plants) YiiP and ZitB (<i>E. coli</i>) CzcD (<i>B. subtilis</i>) ZitA (<i>M. smegmatis</i>)	(MTF-1) ? no CzrA SmtB ?	pdb: 3h90 See Figs. 2, 4 and 5
ZIP	2.A.5	Zn ²⁺ , Fe ²⁺ , Mn ²⁺ , (Cd ²⁺)	Any	Uptake	PM	Zn gradient; PMF? Zn ²⁺ :HCO ₃ ⁻ symport	ZIP1 (<i>H. sapiens</i>) ZIP4 (<i>A. thaliana</i>) ZupT (<i>E. coli</i>) ZRT1 (yeast)	bZIP19 + 23 no ZAP1	Often broad specificity
RND	2.A.6	Cu ⁺ , Ag ⁺ Co ²⁺ , Ni ²⁺ , Cd ²⁺	Gram-negative bacteria	Efflux	Transenvelope	PMF	CusCBA (<i>E. coli</i>) CzcCBA (<i>C. metallidurans</i>) ZneCBA (<i>C. metallidurans</i>) CzrCBA (<i>Caulobacter crescentus</i>)	CusSR CzcSR ZneSR ?	Sensors are two-component systems pdb: 4k0j,3l1n See Fig. 6
ATP-binding cassette (ABC)	3.A.1	Fe ^{2+/3+} , Co, Ni Zn, Mn, Cu, W, Mo, metal chelates (inc. B12, porphyrins, siderophores)	Bacteria, archaea, mitochondria	Uptake or Efflux	PM, IMM	ATP hydrolysis	ZnuABC (<i>E. coli</i>) AdcABC (<i>Streptococci</i>) ZitABC (<i>Lactococci</i>) TroA (<i>Treponema pallidum</i>)	Zur AdcR ZitR	pdb: 2osv, 2ps0,2ogw, 2xqv See Figs. 2 and 3
P(1B)-type ATPases	3.A.3	Cu ²⁺ /Cu ⁺ , Zn ²⁺ . Co ²⁺ , Ni ²⁺ (Cd ²⁺ , Pb ²⁺ , Ag ⁺)	Any, but not necessarily for Zn	Uptake or Efflux	PM, G	ATP hydrolysis	ZntA (<i>E. coli</i>) ZiaA (<i>Synechocystis</i>) HMA2 (<i>A. thaliana</i>) ZosA (<i>B. subtilis</i>)	ZntR ZiaR ? ?	pdb: 4umw, 4umv 1mwz 2kkh See Figs. 2 and 4
Poly-histidine triad proteins	n.a.	Mn ²⁺	<i>Streptococci</i>	Uptake	cell surface	delivers Zn to AdcAII?	PhtD (<i>S. pneumonia</i>)	AdcR	pdb: 3zjf See Fig.8

Table S2. Examples of proteins involved in intracellular (including periplasmic) zinc binding.

	Other metal ions	Organisms	Examples	Regulated by	Remarks
Metallothioneins	Cu ⁺ , Cd ²⁺	Eukaryotes and some bacteria	Mammalian MT2	MTF-1	pdb: 1mrt, 2mrt, 4mt2 2kak, 2l61, 2l62, 2mfp 1jjd See Fig. 9
			Wheat E _C	no	
			SmtA	SmtB	
COG0523	Co, Ni, Fe, Zn (all 2+)		YciC (<i>Bacillus subtilis</i>) YeiR (<i>E. coli</i>) YjiA (<i>E. coli</i>) Also widespread in eukaryotes	Zur Zur not Zn	pdb: 4ixm See Fig. 10
ZinT	-	γ -proteobacteria	ZinT (<i>E. coli</i>)	Zur	
ZraP	-	γ -proteobacteria	ZraP (<i>Salmonella</i>)	ZraSR	pdb :1txl See Fig. 10 pdb :3lay See Fig. 10