Optimisation of Cu, Au, and REE biorecovery by *Shewanella oneidensis*

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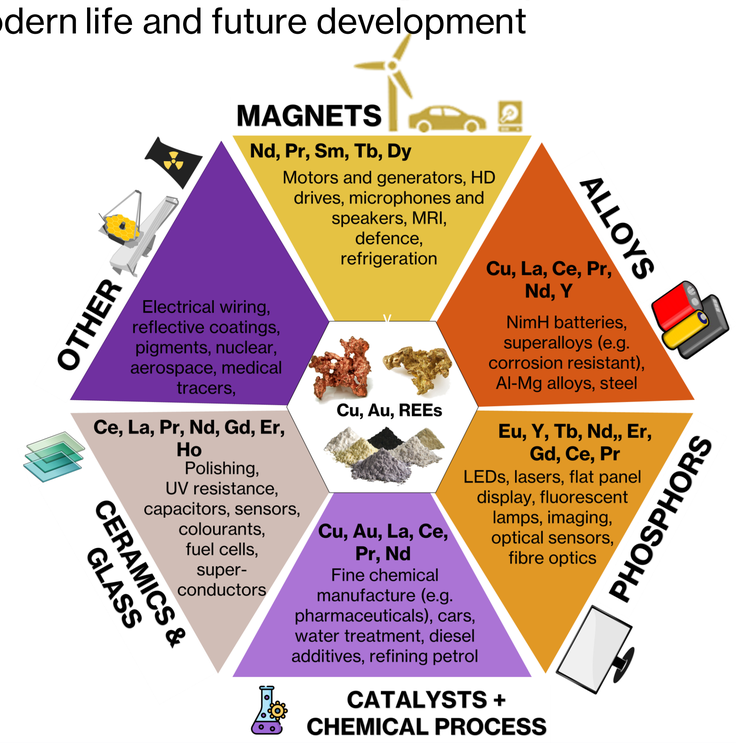
Essential metals for the future...

Cu, Au, REE all have a wide range of important uses essential for modern life and future development



...and widespread contaminants

- Wastes e.g. e-waste, batteries,
- Mining and metallurgical activity
- Effluents e.g. e-waste reprocessing, whiskey distilleries

e.g. some WEEE has higher Cu content than high-grade ores

- Cu, Au, REES difficult/costly to recycle
- Environmental contaminants - toxic & challenging to treat

<< Legacy contamination from a REE mine in **Gahnzou City, China**

Colorado River, USA (2015), Leak from a legacy Au mine contaminants incl. Cu

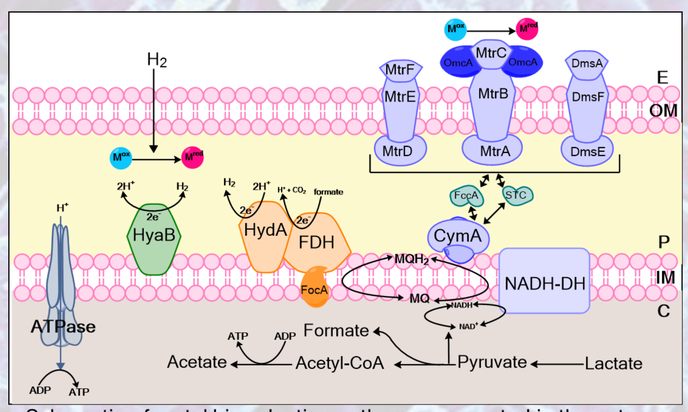
Rio Tinto, Spain >> contamination from >5000 years of mining massive sulfide deposits

Microbes offer a potential bioremediation/recovery solution that may promote the circular economy by producing high-value products such as metal nanoparticles (NPs)

Shewanella oneidensis could help?

$Cu(II)_{(aq)} \rightarrow Cu(0)_{(s)}$
$Au(III)_{(aq)} \rightarrow Au(0)_{(s)}$
} **forms metal NPs** [1, 2, 5]

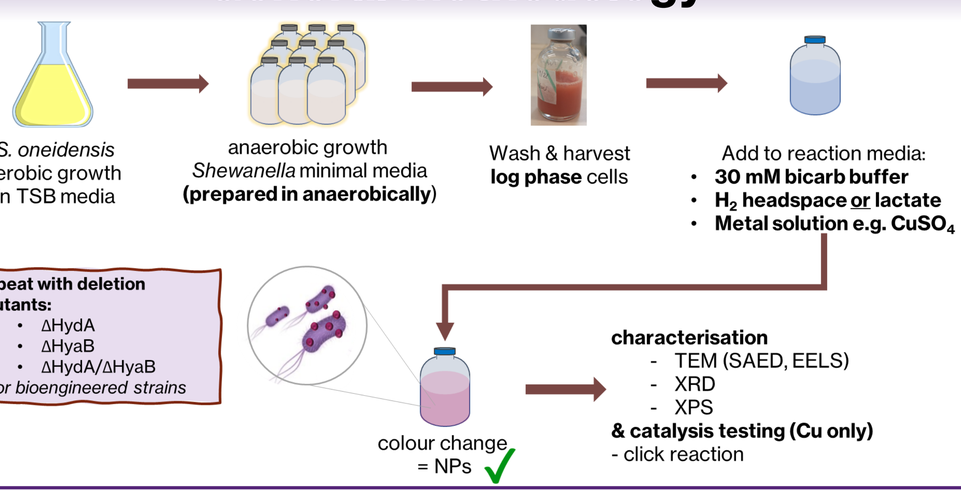
- mechanisms for these reactions not well understood
- **Cu**: cytochrome deletion mutants suggested c-type cytochromes/Mtr pathway not involved in Cu(II) bioreduction[1]
- **REEs (e.g. Ce, La, and Dy)** not redox active - biorecovery expected via biosorption/bioaccumulation... but unexplored thus far



Schematic of metal bioreduction pathways suggested in the outer and inner membranes of *Shewanella oneidensis* [redrawn from 2]

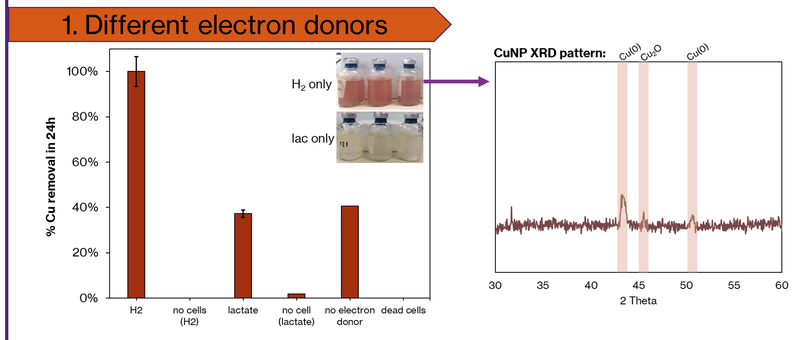
Aim: to gain mechanistic understanding of Cu, Au and REE biorecovery by *S. oneidensis* which is essential for optimisation, bioengineering approaches and to develop feasible and industrially scalable technologies

General methodology

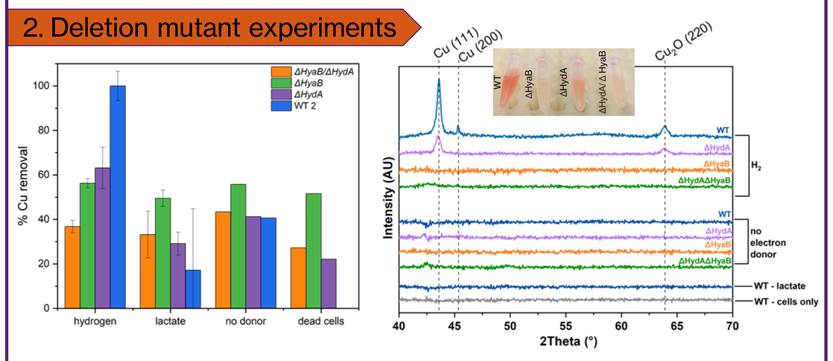


Copper

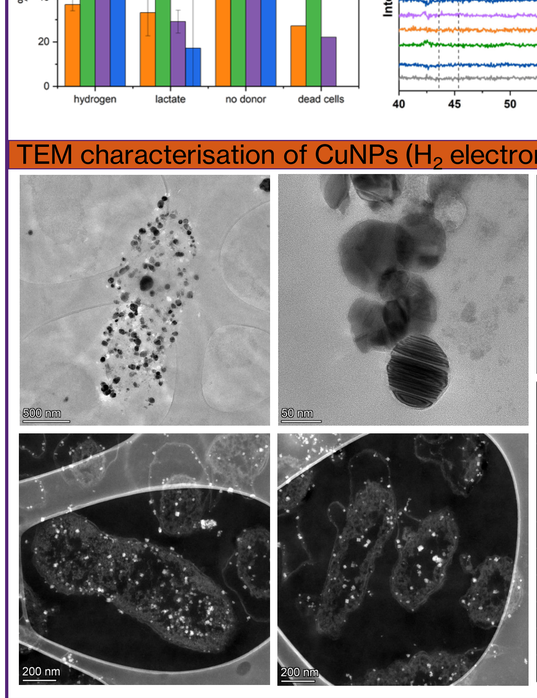
1. Different electron donors

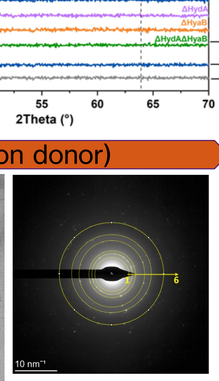


2. Deletion mutant experiments



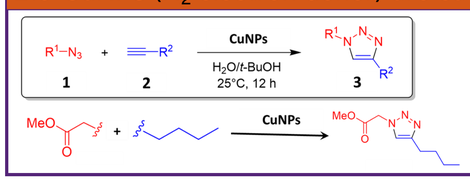
TEM characterisation of CuNPs (H_2 electron donor)

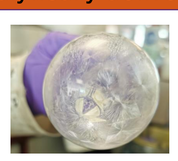




SAED indexing			Literature values[3, 4]	
Ring number	hkl	d-spacing (nm)	Cu	Cu2O
1	111	0.249	-	**0.247**
2	111	0.209	**0.209**	-
3	200	0.182	**0.181**	-
4	220	0.128	**0.128**	-
5	311	0.108	**0.109**	-
6	331	0.082	**0.083**	-

Bio-CuNPs (H_2 electron donor) are catalytically active

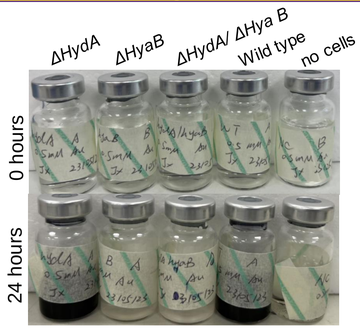


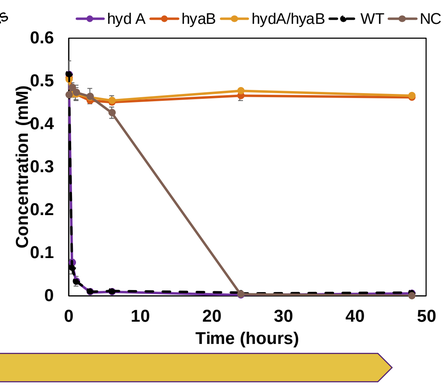


H_1NMH confirmed conversion

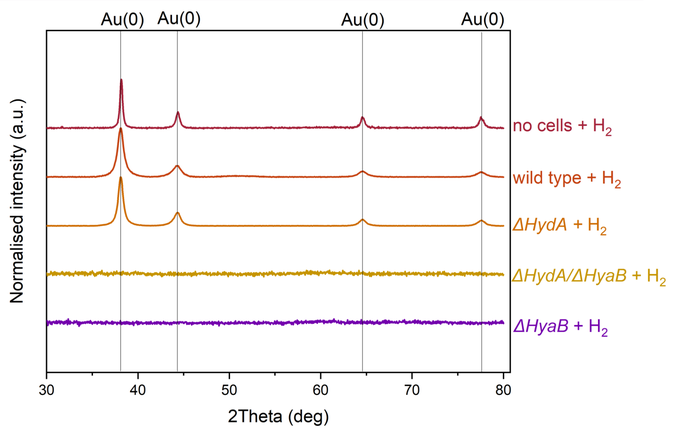
Gold

Au removal (T_0 = 0.5 mM)

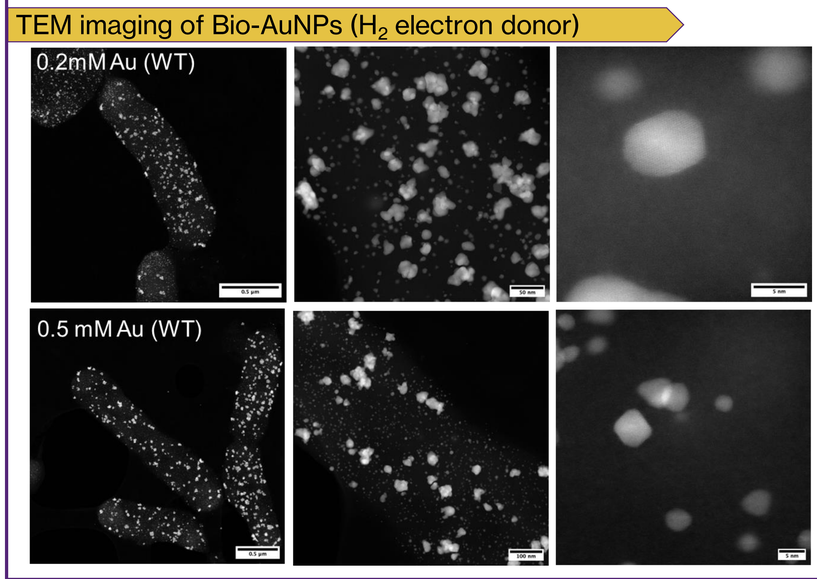




XRD showed Au(0)-NPs

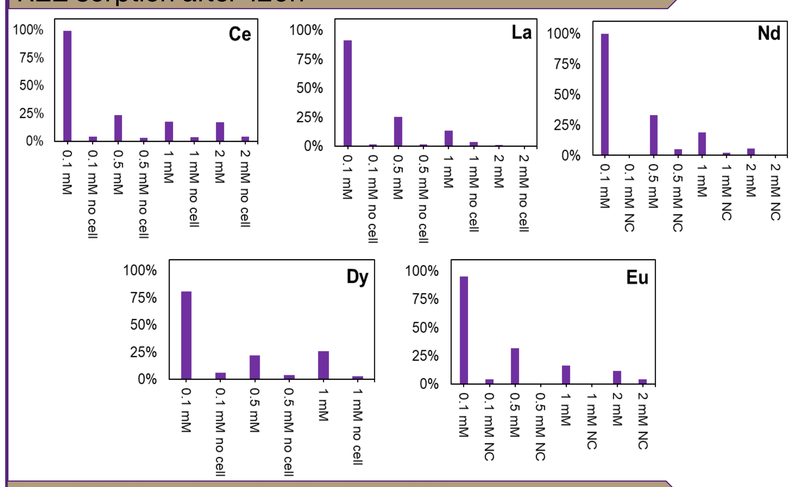


TEM imaging of Bio-AuNPs (H_2 electron donor)

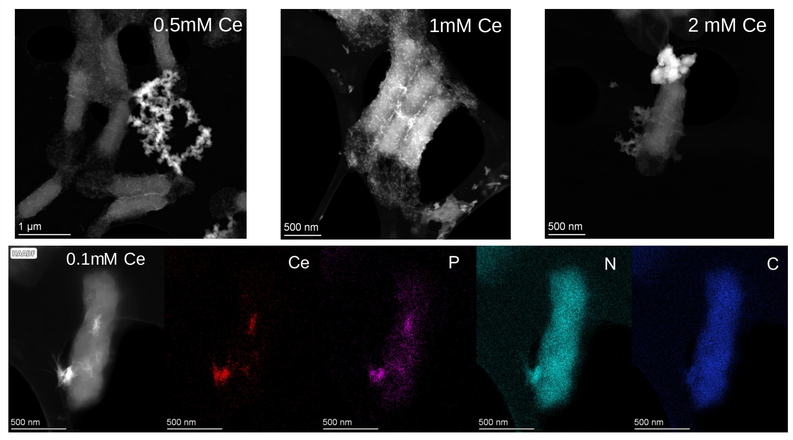


REE

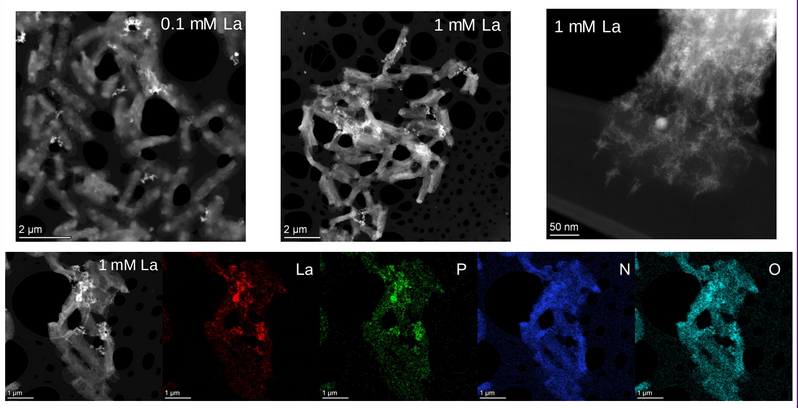
REE sorption after 120h



Ce - TEM imaging of cells after 120h



La - TEM imaging of cells after 120h



References
[1] Kimber *et al.,* (2018) *Small,* 14, 1703145
[2] Egan-Morriss et al., 2021. Nanoscale Advances, 2022, 4, 654
[3] Fernández-Arias *et al.,* (2020) *Applied Surface Science* 507, 145032
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[5] De Corte et al., (2010) J Chem Technol Biotechnol2011;86:547–553