

## Metal Extraction and Biomining

C A Jerez, University of Chile and ICDB Millennium Institute, Santiago, Chile

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### Defining Statement

Microbial Transformations of Metals  
Microorganisms that Solubilize Metals  
Microbial Extraction of Metals from Ores and Biomining  
Acidophilic Microorganism–Mineral Interaction  
Mechanisms Involved in Metal Solubilization by Acidophiles

### Biomining in the Postgenomic Era

Environmental Effects of Metals Solubilization and Bioremediation  
Conclusions  
Further Reading

### Glossary

**biofilm** A layer of adhesive exopolymeric substances attached to a surface and secreted by microorganisms forming colonies on it.

**bioleaching** Refers to the microbial conversion of an insoluble metal (usually a metal sulfide or oxide) into a soluble form (metal sulfate).

**biomining** The use of microorganisms to recover metals in industrial operations.

**bioremediation** Use of microorganisms to remove toxic chemicals from the environment.

**biosorption** Refers to the binding of metal ions by whole biomass (living or dead).

**chemolithoautotroph** A microorganism that fixes CO<sub>2</sub> and obtains its energy by the oxidation of inorganic compounds.

**consortium** A group of microorganisms living together and in which each individual benefits from the others.

**genome** The complete set of genes present in an organism.

**genomics** Refers to mapping, sequencing, and analyzing genomes.

**proteome** The total complement of proteins present in a cell at any one time.

**proteomics** Genome-wide study of the structure, function, and regulation of proteins in the cell.

**systems microbiology** Considers microorganisms or microbial communities as a whole to create an integrated picture of how a microbial cell or community operates.

### Abbreviations

**2D-** Two-dimensional polyacrylamide gel  
**PAGE** electrophoresis  
**AMD** acid mine drainage  
**DGGE** denaturing gradient gel electrophoresis  
**ESI-MS** electron spray ionization MS  
**FISH** fluorescence *in situ* hybridization

**FT-ICR** Fourier transform ion cyclotron resonance  
**MS** mass spectrometer  
**HPLC** High performance liquid chromatography  
**MS** mass spectrometry  
**QS** quorum sensing  
**SDO** sulfur dioxygenase  
**SOR** sulfite oxidoreductase  
**TEM** transmission electron microscopy

### Defining Statement

Microorganisms interact with heavy metals, transforming them by uptake, bioaccumulation, bioprecipitation, bioreduction, biooxidation and other mechanisms. Some of these activities result in the solubilization or extraction of metals which are successfully used in industrial biomining processes to recover valuable metals or in bioremediation to remove toxic metals from contaminated soils.

### Microbial Transformations of Metals

Microorganisms interact with metals by several mechanisms, most of which are shown in [Figure 1](#). All bacteria require several metals that are essential for their functioning and the uptake of most of them is metabolism- or energy-dependent. For this bioaccumulation, they possess specific or general energy-dependent metal transporters to directly incorporate them or through chelation by