

3-2 Protection from Metal Toxicity by a Protein?

— Binding of Heavy Elements to Soluble Glycoprotein on the *Paramecium* Cell Surface —

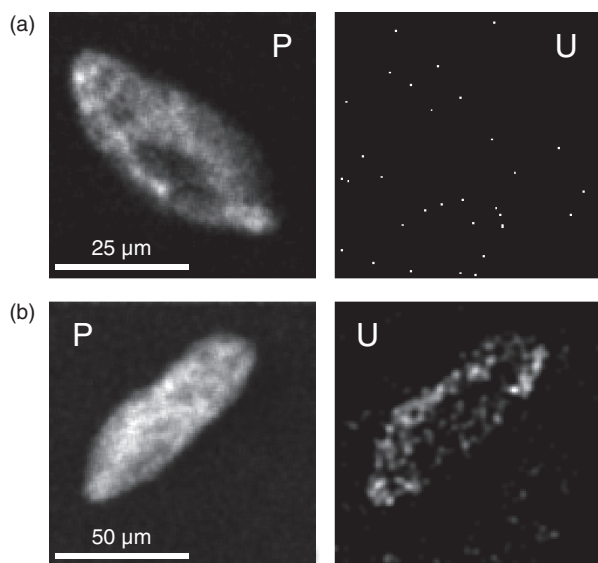


Fig.3-4 Adsorption of uranium on *Paramecium* cells
 (a) Upper side figures are living cells. (b) Lower side figures are prekilled cells. *Paramecium* cells were exposed to aqueous uranium solutions, and the elemental distribution on the cells was measured via a non-destructive elemental analytical method, micro-PIXE. *Paramecium* cells were depicted using phosphorous, which is a major elemental component of cells.

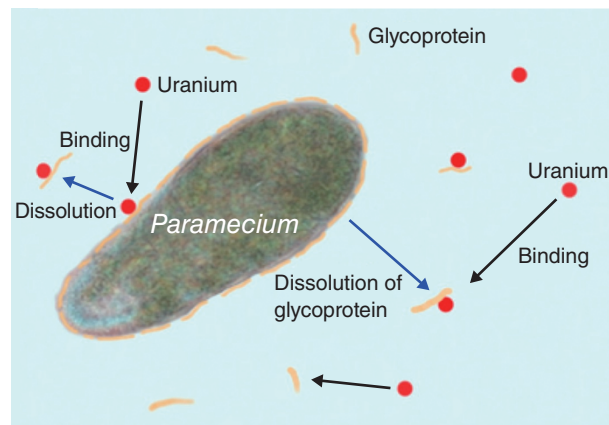


Fig.3-5 Binding of uranium to soluble surface glycoprotein of *Paramecium* cells

Uranium adsorption on living *Paramecium* cells might decrease via one or both of the two mechanisms: (1) when uranium binds to the surface glycoprotein, the uranium-bearing glycoprotein is subsequently dissolved, or (2) uranium binds to the dissolved glycoprotein.

The migration of metal elements (including radionuclides) through geological and aquatic environments is presumably influenced by the biological functions of bacteria, such as adsorption on cell surfaces, phosphate mineralization, reduction, and oxidation. Environmental bacteria lie at the bottom of the ecological pyramid (food chain) in environments co-inhabited by themselves and larger creatures. Bacteria are consumed by protozoa (e.g. paramecia, ameba, and euglena), single-celled microorganisms with lengths of tens to several hundreds of micrometers. These tiny organisms control the bacterial populations. However, the roles of protozoa on the environmental migration of metal elements have not been previously investigated. To elucidate these roles, this study investigates the interaction between a representative freshwater protozoan (*Paramecium* sp.) and a metallic element (uranium).

Paramecium cells were exposed to aqueous uranium solutions in the laboratory. Uranium adsorbed on living cells was hardly detected using an element analytical device but was clearly detected on dead cells analyzed via micro-particle induced X-ray emission (micro-PIXE). Here, the *Paramecium* cells were killed using chemicals (fixatives) before running

the experiment (Fig.3-4). After the experiment, we probed the cause of this large difference by analyzing the liquid phase. We found that a fraction of the uranium was bound to an organic substance released from living *Paramecium* cells. This organic substance was a large soluble glycoprotein with an approximate molecular size of 250 kDa.

The characteristics of the organic substance accorded with those of the glycoprotein covering the entire cell surface of *Paramecium*. This finding strongly suggests that dissolution of the uranium-binding glycoprotein from the living cell surface reduced the level of the adsorbed uranium to below the detection limit of the micro-PIXE instrument (Fig.3-5). Meanwhile, the uranium on the prekilled cells remained because the surface glycoprotein was chemically fixed to the cells.

Paramecium is sensitive to and poorly resistant to metal elements. Although the role of glycoprotein on the *Paramecium* cell surface is only partially understood, it may protect the cell surface from metal toxicity.

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Reference

Kozai, N. et al., Complexation of Eu(III), Pb(II), and U(VI) with a *Paramecium* Glycoprotein: Microbial Transformation of Heavy Elements in the Aquatic Environment, *Chemosphere*, vol.196, 2018, p.135-144.