Foreword

The Organizing Committee of the IBS 2015 received over **180 short abstracts** from **more than 24 different countries** around the world. After acceptance, most authors submitted 4-page extended versions, detailing their work. These–were reviewed by members of the **International Scientific Committee,** which is made up of prestigious researchers and experts in the field of Biohydrometallurgy. Based on requirements of scientific quality, over 160 extended versions were accepted for publication in this book, the selected Proceedings of the **21st International Biohydrometallurgy Symposium** held in Sanur, Bali, Indonesia, on October 5-9, 2015.

The Symposium was organized around six main topics:

- fundamentals and application of bioleaching;
- microbe-mineral interactions; bioflotation, biobeneficiation, biosorption and bioaccumulation;
- geomicrobiology, biogeochemical cycles, genetics and molecular biology;
- microbial corrosion and bio-electrochemistry;
- mining impact, bioremediation of metals and mine wastes.

The ninety six oral presentations and sixty six posters were presented over five days as experts in academia, research institutions and industry exchanged information and ideas about this interdisciplinary process, with the aim of highlighting frontiers of knowledge and stimulating a new generation of young researchers and university students.

We wish **to acknowledge and thank Professor David Holmes** for not only kindly accepting our invitation to give the opening lecture of the Symposium, but also for his many years in inspiring young (and older) members of the biohydrometallurgy global community.

Finally, the members of the IBS 2015 Organizing Committee hope that the success of the 21st IBS, and the Proceedings included in this book, **contribute to our knowledge and understanding of Biohydrometallurgy, and help promote the integration of biotechnologies in the mining industry and the environmental sectors.**

M. Zaki Mubarok and Siti Khodijah Chaerun (Chairs IBS 2015)

Honouring Henry L. Ehrlich

Henry L. Ehrlich

The IBS community would like to congratulate Professor HenryLutz Ehrlich on his 90th birthday and recognize him for his many contributions to the field of Geomicrobiology.

Dr. Ehrlich was born in 1925 in Stettin, Germany which, after the war, became the town of Szczecin in Poland. In 1940 he emigrated with his family to the United States, developing an interest in microbiology as a high school student. Early recognition of his potential led to his attending and majoring in Biochemical Sciences at Harvard College, where he graduated in 1948 with a BS. He later earned his MS degreeat the University of Wisconsin in Madison, where in 1951 he also completed his PhD in Agricultural Bacteriologywith a minor in Biochemistry. He thenjoined the faculty of the Department of Biology at Rensselaer Polytechnic Institute (RPI) in Troy, New York where, until he retired in 1994, he taught and conducted research on topics ranging from sulfide biooxidation, manganese oxidation and reduction, chromium reduction and bauxite beneficiation.

Testifying to the interdisciplinary collaborations so critical to geomicrobiology, his initial scientific research with *Acidithiobacillus*(then *Ferrobacillus*) *ferrooxidans*began in 1958 as a discussion with a colleague from the Faculty of Geology. Thus, it was as an assistant professor at Rensselaer that he was to begin pioneering work in geomicrobiology, when column biooxidation experiments with pyrite, pyrrhotite and sphalerite were carried out in his laboratory. In the early 1960s, he examined the association of acidophilic microbial populations with sulfide minerals and then expanded his investigations to include copper leaching from chalcocite and chalcopyrite, as well as demonstrating by 1963 that orpiment could be microbially oxidized and by 1964 that this was also true for enargite and arsenopyrite.This led his lab to later investigate microbial arsenite oxidation. In 1986, he described microbial leaching of silver from a mixed sulfide ore. His lab continued to investigate selective silver leaching from manganese ore and mixed sulfides until 1988 and 1990, respectively.

Since the 1960s, he also did continuous research work on the microbial formation of manganese nodules and ferromanganese concretions in the deep sea, as well asmanganese-oxidizing bacteria from hydrothermal vents and biogeochemical cycling of manganese in freshwater and marine environments. Requiring fresh nodule samples for growth dependent studies, he was not content to remain in the lab but participated in four oceanographic expeditions. Nodules were found to be associated with both manganese-oxidizing and manganese-reducing populations. Manganese accretion was demonstrated to occur at hydrostatic pressures related to the depth at which marine nodules were known to exist. Oxidation was demonstrated for manganese sorbed to certain clays or manganese oxide. His current model for oxidation of manganese sorbed on ferromanganese solids or certain clays is consistent with a direct microbial role in their formation.Cell free-studies performed by his group linked manganese oxidation to ATP production.

Beginning in 1977, he and a number of students examined aspects of microbial chromate reduction.

Finally, in 1992, he began examiningbiogeochemical maturation of lateritic bauxitic ore – microbially augmented mobilization of silica and reduction and mobilization of ferric iron associated with contaminating iron-bearing minerals. While the biobeneficiation was of great practical interest, the study also revealed a new conceptual area of investigation - how iron was being reduced and mobilized beneath the mineral surface.

In addition to his own research activities, Dr. Ehrlich worked on several fronts to expand scientific knowledge. In 1966, he began teaching a course in geomicrobiology at Rensselaer. He continued to teach the course until his retirement in 1994. In 1981 he published the first edition of a textbook on this subject and this and later editions became standard literature for scientists working in the fields of geomicrobiology and microbial leaching.Together with some others, he initiated the very first International Symposium onEnvironmental Biogeochemistry in 1971 and this hassince continued biannually. From 1983 to 1997,Dr. Ehrlich worked as editor-in-chief of *Geomicrobiology Journal*, then co-editor from 1997 to 2011 and now as an editor emeritus.

It's difficult to do justice to such a productive scientific career. In contrast, he himself truly does justice to the word "Scientist" – justice to the words "Scholar" and "Teacher"– justice to the word –'Mentor". And so, on this occasion, we wish to honour him as a revered member of our large group of researchers from all over the world in the fields of geomicrobiology and biohydrometallurgy.

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