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Editorial

Metals Are Main Actors in the Biological World

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1. Introduction and Scope

The word "metallomics" was introduced for the first time in 2004 [1] to describe the emerging scientific field of investigation addressing the role that metal ions have in the biological world, including their trafficking, uptake, transport, and storage. The field has expanded enormously in more recent years [2–4] and now contributes to an understanding of the molecular mechanisms of all metal-dependent biological processes, be they endogenous or exogenous metal-induced, the latter opening up unlimited possibilities in terms of metal-related therapies. The new field of "metals in medicine" has therefore thrived, and scientists have taken up this therapeutic challenge, trying to both (i) modulate metal-related processes through chelation therapies that target endogenous metal ions dyshomeostasis and/or (ii) synthesize and administer metal compounds, which can be also used for diagnostic and/or theranostic purposes. The wide variety of studies within the field of metallomics has consequently requested a wide range of investigation techniques and expertise that span from mass spectrometric methods to biochemical techniques. This special issue is meant to gather scientific contributions from authors working in the various fields of metallomics, providing examples of the role of metal ions in neurodegeneration, the analytical techniques applied to investigate metal ions in vivo and in vitro, and the use of metal complexes for therapeutic purposes, as well as the possibility to follow the destiny of toxic metal ions that might be ingested by living creatures. This special issue, albeit not high in terms of quantity, provides a fair overview of the wide and interesting field of research that is hidden behind the word "metallomics", putting this relatively new "omic" science at the center of the scientific scene.

2. Contributions

Metals in living organisms have very different roles depending on their intrinsic characteristics, redox properties, charge, and, above all, size. Indeed, in this special issue, attention is paid to very different metals, zinc and iron, which have completely different roles in living organisms. The paper by Angelova et al. [5] provides an insight on the role of metals and iron, in particular in the aging process and as causative factors involved in neurodegeneration. It is clear from this work that metals in biology are a proverbial "double-edged sword", i.e., they are vital for the activity of a number of critical enzymes and cell processes, yet their dyshomeostasis causes pathological effects that damage both the organism in general and cells in particular. Such an aspect is very clear also in the paper by Ollig et al. [6], that, in addition to describing the role of zinc in living organisms, deals with the methodological problems and pitfalls related to measuring intracellular free zinc levels, elucidating the technical problems correlated to the in vivo investigation of the metallomics world.

Other papers of this special issue explore the other large metallomics sub-field involving the use of metal complexes for therapeutic purposes. On this note, Barai et al. [7] investigate the interaction and binding modes of bis-Ruthenium(II) complexes to synthetic DNAs, exploring the possibilities that newly synthesized metal complexes can interact with DNA for cancer therapies. Analogously, Pantelić et al. [8] synthesized a new gold compound that shows promising antitumor

activities against the cell lines scrutinized. These two contributions are just examples of the enormous therapeutic potential and societal impact that the work of inorganic chemists can have in the near future. It is auspicable that various specifically designed metal complexes will be available in clinics as side-effect-free drugs for different specific forms of cancer, as is already the case for some of them [9].

As mentioned in the introduction, metallomics is a wide expanding field for scientists interested in all of the possible correlations between metal ions and living organisms. From this perspective, the work of Carreño-Fuentes et al. [10] investigates the possibility of using biomolecules to produce water-soluble metal nanoparticles with an exquisite control over their size and shape, reporting a study of palladium nanoparticles directly attached to recombinantly produced VP6 tubular assemblies, producing an integrative hybrid nanomaterial with great control over the Pd particle size and arrangement over the biotemplates.

Finally, another important sub-field of metallomics is well represented by the work of Kobayashi et al. [11], who explore the "distribution and excretion of arsenic metabolites after oral administration of seafood-related organoarsenicals in rats", demonstrating the possibility of monitoring the metabolites of toxic metal ions in living organisms. The paper shows important experimental issues encountered in these kinds of studies and is a good example of the work that has to be done in order to obtain standard procedures to correctly evaluate toxic levels of metal ions in living organisms, taking into account the transformation that these types of metal complexes undergo once they are inside an organism.

3. Conclusions and Outlook

It is clear that metallomics is an interdisciplinary field of research that has great potential of development. A prominent feature of many pathological conditions is metal ion dyshomeostasis, which has to be interpreted not merely as a change of metal level and concentration, but also and more importantly as a disruption of their correct trafficking and compartmentalization, as well as the consequent changes in the active metal-complex species. The complexity of the subject is very challenging for scientists who often have to resort to many different and complementary experimental techniques in order to tackle the problems correlated with metal ion dyshomeostasis, which are at the base of many pathologies. On the other hand, the complicated but fascinating metallomics scenario, intertwined with other omics such as proteomics, genomics, and metabolomics, offers unique therapeutic opportunities that can be designed once the biochemical mechanisms involving metal ion homeostasis are completely unveiled and understood. For this reason, I hope that this special issue on metallomics will help to increase the interest towards this expanding and still mostly unexplored field of research.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Haraguchi, H. Metallomics as Integrated Biometal Science. *J. Anal. At. Spectrom.* **2004**, *19*, 5–14. [CrossRef]
2. Shi, W.; Chance, M.R. Metallomics and metalloproteomics. *Cell. Mol. Life Sci.* **2008**, *65*, 3040–3048. [CrossRef] [PubMed]
3. Szpunar, J. Advances in analytical methodology for bioinorganic speciation analysis: Metallomics, metalloproteomics and heteroatom-tagged proteomics and metabolomics. *Analyst* **2005**, *130*, 442–465. [CrossRef] [PubMed]
4. Haraguchi, H. Metallomics: The history over the last decade and a future outlook. *Metallomics* **2017**, *9*, 1001–1003. [CrossRef] [PubMed]
5. Angelova, D.M.; Brown, D.R. Iron, Aging, and Neurodegeneration. *Metals* **2015**, *5*, 2070–2092. [CrossRef]
6. Ollig, J.; Kloubert, V.; Weßels, I.; Haase, H.; Rink, L. Parameters Influencing Zinc in Experimental Systems In Vivo and In Vitro. *Metals* **2016**, *6*, 71. [CrossRef]
7. Barai, H.R.; Lee, D.J.; Han, S.W.; Jang, Y.J. Interaction and Binding Modes of *bis*-Ruthenium(II) Complex to Synthetic DNAs. *Metals* **2016**, *6*, 141. [CrossRef]

8. Pantelić, N.; Zmejkovski, B.B.; Marković, D.D.; Vujić, J.M.; Stanojković, T.P.; Sabo, T.J.; Kaluđerović, G.N. Synthesis, Characterization, and Cytotoxicity of a Novel Gold(III) Complex with *O*,*O*′-Diethyl Ester of Ethylenediamine-*N*,*N*′-Di-2-(4-Methyl)Pentanoic Acid. *Metals* **2016**, *6*, 226. [CrossRef]
9. Dasari, S.; Tchounwou, P.B. Cisplatin in cancer therapy: Molecular mechanisms of action. *Eur. J. Pharmacol.* **2014**, *5*, 364–378. [CrossRef] [PubMed]
10. Carreño-Fuentes, L.; Bahena, D.; Palomares, L.A.; Ramírez, O.T.; José-Yacamán, M.; Plascencia-Villa, G. Molecular Docking and Aberration-Corrected STEM of Palladium Nanoparticles on Viral Templates. *Metals* **2016**, *6*, 200. [CrossRef]
11. Kobayashi, Y.; Hirano, S. Distribution and Excretion of Arsenic Metabolites after Oral Administration of Seafood-Related Organoarsenicals in Rats. *Metals* **2016**, *6*, 231. [CrossRef]