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Special Section of Papers presented at the Larry L. Hench Memorial Symposium on Bioactive Glasses at the Annual Meeting of the Glass & Optical Materials Division (GOMD) of the American Ceramic Society, held from 22nd to 26th May 2016 in Madison, Wisconsin, USA

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Bioglass® has revolutionised orthopaedic and maxillofacial surgery and dental healthcare. Why? Because it was the first synthetic material found to form a bond with bone [1]. The impact on the field of glass science is massive. Who would have thought a glass could regenerate human tissue? Bioglass has propelled glass into a whole new application area. It also founded a whole field of biomaterials: bioactive materials. Before Larry Hench discovered Bioglass® in 1969 (published in 1971 [1]), implant materials were selected primarily for their corrosion resistance. The problem is that these implants were encapsulated by fibrous tissue – if a sterile window glass was implanted in a bone, it would be isolated by fibrous tissue. Bioglass 45S5, the first composition Larry tried, instead formed a tight bond to bone.

This special section follows the Larry Hench Memorial Symposium at GOMD 2016 (the American Ceramic Society's Glass and Optimal Materials Annual Meeting) in Madison, Wisconsin. Larry was an active member of the society, having been awarded most of their awards, including their highest honour of the Distinguished Life Membership, and he gave his last podium presentation at the GOMD 2015 meeting in Miami, Florida. He passed away on 16th December 2015 at the age of 77. Larry was an amazing human being: a great scientist, an artist (he painted), an author (he wrote a series of children's books on Boing Boing the Bionic Cat) and a wonderful mentor and friend. The latter is evident by how many past students are now in faculty positions around the world.

His scientific accomplishments include of course the discovery of Bioglass [2], the first bone bonding material, but he also developed bioactive sol-gel glasses [3] and uncovered the mechanisms for the bone bonding (hydroxycarbonate apatite formation following glass corrosion) [4] and for stimulation of new bone growth (gene activation in osteoprogenitor cells) [5]. As Bioglass degrades, it releases cations that signal cells. The prospect of including other cations in glass will lead to many other therapies [6], including repair of soft tissues, including wound healing [7]. Bioglass is also used as a mineralisation agent in toothpaste [8, 9].

Before Larry worked on Bioglass, he also worked on nuclear waste encapsulation and was working on electroceramics when he was challenged by US Army Colonel, on a bus ride, to develop a material that could

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survive the aggressive environment of the human body. This ultimately led to the discovery of Bioglass [10], which launched the field of bioactive materials. Larry was involved in founding many of the key Biomaterials Societies, such as the Society for Biomaterials and was highly decorated, including the MRS Von Hippel Award and the Acta Biomaterialia Gold Medal. He was also elected to the US National Academy of Engineering.

This special section comprises six articles that build on the Hench legacy and which were presented at the Larry L. Hench Memorial Symposium in Madison, Wisconsin, 2016. They include studies on typical Hench-type bioactive phospho-silicate glasses, including their dissolution behaviour and cell response, but also other glasses for use as biomaterials including phosphate and borate glasses and bioactive glass nanoparticles. Together, these papers give an overview on some current directions in bioactive glass, and highlight possible future trends in bioactive glass research.

References

[1] Hench L.L., Splinter R.J., Allen W.C., Greenlee T.K., Bonding mechanisms at the interface of ceramic prosthetic materials, J Biomed Mater Res Symp, 1971, 2, 117–141.

[2] Hench L.L., Some comments on Bioglass: Four Eras of Discovery and Development, Biomedical Glasses, 2015, 1, 1–11.

[3] Li R., Clark A.E., Hench L.L., An investigation of bioactive glass powders by sol–gel processing, Journal of Applied Biomaterials, 1991, 2, 231–239.

[4] Hench L.L., Paschall H.A., Direct chemical bonding of bioactive glass–ceramic materials and bone, J. Biomed. Mater. Res. Symp., 1973, 4, 25–42.

[5] Hench L.L., Polak J.M., Third–generation biomedical materials, Science, 2002, 295, 1014–1017.

[6] Hoppe A., Gueldal N.S., Boccaccini A.R., A review of the biological response to ionic dissolution products from bioactive glasses and glass–ceramics, Biomaterials, 2011, 32, 2757–2774.

[7] Miguez-Pacheco V., Hench L.L., Boccaccini A.R., Bioactive glasses beyond bone and teeth: Emerging applications in contact with soft tissues, Acta Biomater, 2015, 13, 1–15.

[8] Mneimne M., Hill R.G., Bushby A.J., Brauer D.S., High phosphate content significantly increases apatite formation of fluoride–containing bioactive glasses, Acta Biomater, 2011, 7, 1827–1834.

[9] Earl J.S., Leary R.K., Muller K.H., Langford R.M., Greenspan D.C., Physical and chemical characterization of dentin surface, following treatment with NovaMin® technology, J. Clin. Dent., 2011, 22, 2–67.

[10] Jones J.R., Review of bioactive glass: From Hench to hybrids, Acta Biomater, 2013, 9, 4457–4486.