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Biological Materials of Marine Origin

Vertebrates

Springer

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Preface

The higher chordate subgroup includes all the vertebrates: fish, amphibians, reptiles, birds, and mammals. All of them are found in marine environments and coastal regions. Probably the animal that more closely defines human thoughts of life in the sea is a fish. In fact, fish are an ancient group of animals whose origins date back more than 500 million years. They are the most common and diverse group of animals with backbones in the ocean and in the world today.

These animals are the real goldmine for material scientists because of their astonishing variety of shapes and sizes, as well as the diversity of biological materials that compose their organs and structures. Herein are only a few examples. Fish possess structures as barbels, claspers, denticles, scales, egg-cases, oral and pharyngeal teeth, bones, otoliths, cartilage, swim bladders, sucking disks, epidermal brushes, fins, pelvic spines and girdle, gills and bony operculums, unculi and breeding tubercles, and even wings in the case of flying fish. All of the listed structures are hierarchically organised from nano to micro and macro scales. They possess very specific biopolymers like collagens, elastoidines, elastins, keratins, and other cross-linked structural macromolecules. Moreover, we can also find such unique biocomposites of fish origin with exotic names as hyaloine, ganoine, or cosmine. Did you know that terms as enameloid, adameloid, coronoin, acrodin, and prelomin are related to fish scales? Or the recent research detailing differences between orthodentine and osteodentine, durodentine and vasodentine, plicidentine and mesodentine, semidentine and petrodentine, or elasmoidine, as forms of dentine in different fish species? If no, I hope you are now intrigued by this book, which was announced in my first monograph entitled *Biological Materials of Marine Origin: Invertebrates* published by Springer in 2010.

In addition to fish, I also analyse biological materials from marine turtles, iguanas, snakes, and crocodiles as well as sea birds. Special attention is paid to whales and dolphins, as representatives of marine mammals. In terms of species number, marine mammals are a relatively small taxonomic group; yet given their biomass and position in the food web, they represent an ecologically important part of marine biodiversity. Furthermore they are of significant conservation concern, with 23 % of species currently threatened by extinction. Therefore, marine mammals often feature prominently in marine conservation planning and protected area design.

Both non-mineralized and biomineral-containing structures have been described and discussed. Thus, bone, teeth, otoconia and otoliths, egg shells, biomagnetite, and silica-based minerals are analyzed as biominerals. A separate chapter is dedicated to pathological biomineralization. Furthermore, in this book, I take the liberty to introduce the term "Biohalite" for the biomineralized excretion produced by the salt glands of marine fish, reptiles, and birds. Further chapters are dedicated to material design principles, tissue engineering, material engineering, and robotics. Marine structural proteins are discussed from the biomedical point of view.

Altogether, the recent book consist of four parts: 14 chapters, including Introduction, addendums, an epilogue, and addendums to each chapter including more than 2,000 references. Many of the photos are shown here for the first time. I have also paid much attention to the historic factors, as it is my opinion that the names of the discoverers of unique biological structures should not be forgotten. As this is highly interdisciplinary research, fully satisfying the curiosity of expert readers is difficult to do in this rather short survey of a very broad field. However, I hope it will provoke thought and inspire further work in both applied and basic research areas.

There are so many institutions and individuals to whom I am indebted for the gift or loan of material for study that to mention them all would add pages to this monograph. It may be sufficient to say that without their cooperation, this work could hardly have been attempted. First of all, I am very grateful to Prof. Kurt Biedenkopf and his wife Mrs. Ingrid Biedenkopf as well as to the German Research Foundation (DFG, Project EH 394/3-1) for financial support. I also thank Prof. Catherine Skinner, Prof. Edmund Bäeuerlein, Prof. Victor Smetacek, Prof. Dan Morse, Prof. Peter Fratzl, Prof. Matthias Epple, Prof. George Mayer, Prof. Christine Ortiz, Prof. Marcus Buehler, Prof. Andrew Knoll, Prof. Adam Summers, Prof. Stanislav N. Gorb, Prof. Arthur Veis, Prof. Gert Wörheide, Prof. Alexander Ereskovsky, Prof. Hartmut Worch, and Prof. Dirk-Carl Meyer for their support and permanent interest in my research. Especially I would like to thank Prof. Bernd Meyer and Dr. Andreas Handschuh for the excellent scientific atmosphere at TU Bergakademie Freiberg where I enjoyed the time to prepare this work. I am grateful to Prof. Joseph L. Kirschvink, Dr. Martin T. Nweeia, and Dr. Regina Campbell-Malone for their helpful discussions of some chapters, and to Dr. Vasilii V. Bazhenov, Marcin Wysokowski, Dr. Andrey Bublichenko, Dr. Yuri Yakovlev, Alexey Rusakov, and Andre Ehrlich for their technical assistance. To Dr. Allison L. Stelling, I am thankful for taking excellent care of manuscripts and proofs. To my parents, my wife, and my children, I am under deep obligation for their patience and support during the years.

Freiberg, Germany Hermann Ehrlich

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