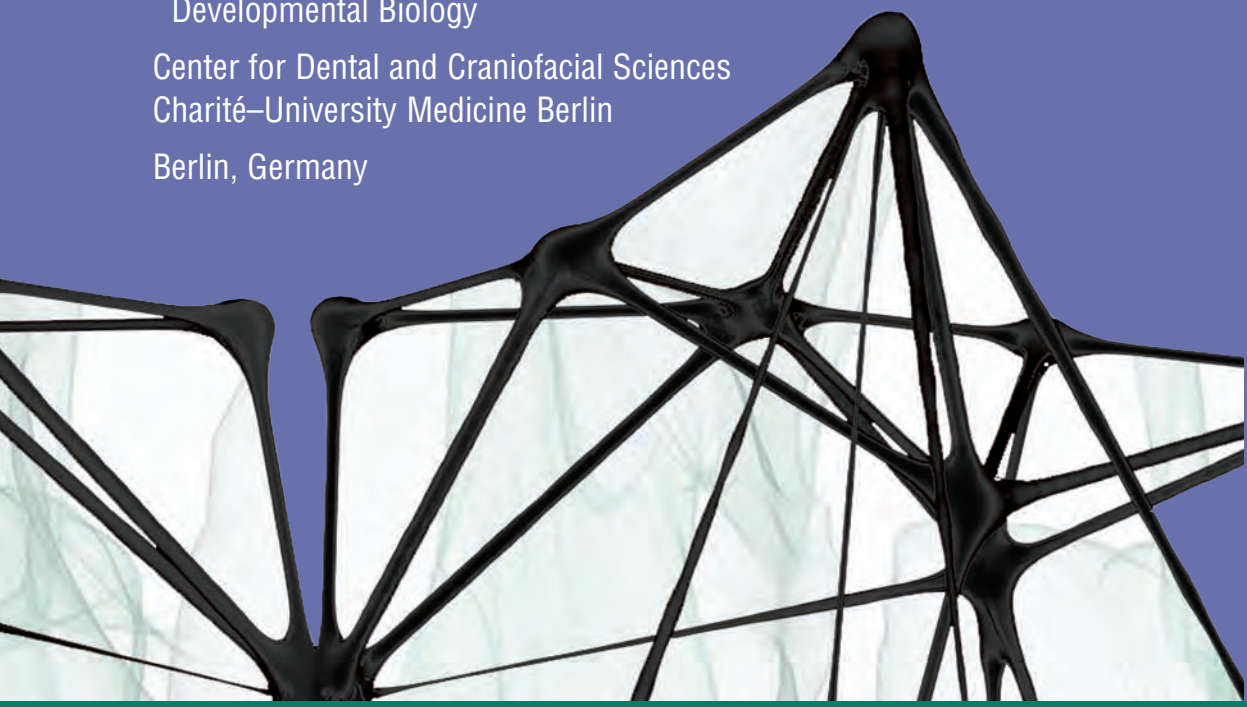
Oral Structure & Biology

Ralf J. Radlanski

Director, Department of Craniofacial Developmental Biology

Center for Dental and Craniofacial Sciences
Charité–University Medicine Berlin

Berlin, Germany



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Dedication

This book is dedicated to all those who seek to preserve knowledge, to critically review and expand it, and to use it to treat their patients responsibly.

This book was originally published in German under the title *Orale Struktur- und Entwicklungsbiologie*.

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Preface

It has been more than 10 years since Hubert E. Schroeder, Professor of Oral Structural Biology in Zürich and author of the book of the same name, asked me to produce a new textbook that would maintain and expand on the basic knowledge he had assembled.

When he retired, he entrusted to me a large proportion of his original illustrations so that they could be retained in the new book. As a student, I used his textbook as a study tool. At the time, I naturally had no idea I would one day be in a position to continue his legacy.

Over the intervening years, not only has our knowledge of morphology and developmental biology in the orofacial region greatly expanded, but our reading and learning habits have changed considerably. This change affects the structure of thought processes and sentence structure as well as the visual presentation of text and illustrations. A new book titled *Oral Structural and Developmental Biology* emerged from the experiences I gained during many years of lecturing on these topics at Göttingen University and the Free University of Berlin as well as the University of California at San Francisco and the University of Turku.

It is very important to be able to hold in our hands a compendium of the structural biologic foundations of clinical work in dental and oral medicine, especially today, as it is difficult to keep track of the growth in knowledge and molecular medicine is constantly growing in importance.

As the author, I am solely responsible for the content of this book, but a large number of highly committed colleagues have constantly given me valuable help over the years. First and foremost, I would like to thank Dr Herbert Renz, Dipl-Biol, for lots of in-depth discussions in which he saved me from making many a mistake. In addition, he prepared numerous specimens and laboriously photographed them under light and electron microscopes. I also wish to thank Dr Christine Knabe und Prof Dr Andrea-Maria Schmidt-Westhausen for checking some of the chapters. I am grateful to my secretary, Beate Lion, for doing the legwork on the literature search and maintaining the literature database as well as doing preparatory work on some of the illustrations. I would also like to thank medical technicians Barbara Danielowski, Irene Schwarz, and Karin Schulze-Dirksen for preparing many of the histologic specimens, photographs, and 3D reconstructions based on serial histologic sections.

Many students trial-read various passages and passed on their comments. Representative of all these students, I would like to thank Anne Schöler and Saskia Preisner, as well as my children Jana, Kalinka, and Philip Radlanski. As one of my peers, Prof Dr Birte Steiniger from Marburg University gave me numerous explanatory notes on the chapter dealing with the immune system, for which I sincerely thank her. Prof Dr Werner Götz of Bonn University rigorously worked through large parts of the manuscript and gave me valuable notes, for which I am extremely grateful.

My thanks to Johannes Wolters, the Publishing Director of Quintessenz in Berlin, for the patience he showed despite the delays. He recognized a real need for this unique book on the subject of oral structural and developmental biology. I thank him especially for his willingness to produce many of the illustrations in expensive color print.

This book was written primarily for students of dental and oral medicine. Students tackling the book in their first term will undoubtedly find the sheer amount of material and the high level of detail rather overwhelming. However, as they expand their horizons during the course of their studies and whenever clinical necessity calls for knowledge of the fundamentals of structural biology, I hope they will be able to find the correct answers in this book. I also hope this will prove a helpful reference work after readers have completed their studies. Furthermore, this book may provide the foundation for further study in related fields, such as anthropology, forensic medicine, or veterinary medicine.

I always found working on the text to be extremely instructive, fascinating, and at times more exciting than a Sunday evening crime thriller on the TV. I hope everyone working through this book has the same experience!

CHAPTER 1

Definitions, Objectives, and Clinical Relevance

The difference between health and sickness can be seen even in the mouth, based on changes in form and structure from the macroscopic to the microstructural. Knowledge of the structures and pathologic changes to those structures enables practitioners to successfully treat patients or seek treatment options. This book presents the structural biologic foundations underpinning dental and oral medicine.

The mouth encompasses the area between the lips and the throat. All the parts are described in terms of their form, composition, tissue structure, and cellular properties. In many cases, the structural makeup only becomes comprehensible once its origins are understood. This is why aspects of development are described, ranging from embryonic development to changes in old age.

Clinical examination and treatment are influenced by patient morphology as understood through visual and haptic impressions. However, these aspects are based on the microstructure of the organs and tissues. Because this structure is not visible to the naked eye in most cases, our knowledge relies on rigorous examination using radiology, light microscopy, and electron microscopy. Knowledge is also gained through objective experiments. However, patience and sometimes substantial investment in laboratory equipment are needed to bring patterns and connections to light.

When dealing with a patient, the full range of knowledge and all available facts may not be needed. Nevertheless, the more fundamental knowledge practitioners have on which to base their work, the more successful they will be. People should not be frustrated if the odd fact escapes them every now and then. Understanding the connections between the facts is what matters most. However, these connections are only revealed after a thorough study of the facts. It is our duty to our patients to know exactly what we are doing. Patients will rarely go along with suppositions and a trial-and-error approach.

A large proportion of the material presented in this book is based on knowledge that was gained using human subjects. However, some experiments can only be done in animals. Not all findings are transferable to humans; where statements in the text apply only to a specific experimental animal, a note is given to that effect. To show links between fundamental knowledge about structural biology and patients, clinical notes are given where appropriate. Because our knowledge is still incomplete, reference is made in several places to unanswered questions.

Nevertheless, most morphologic and microstructural knowledge can be regarded as accepted fact. New findings in this sphere are rare. While modern research focuses on

questions of molecular biology, structural biology remains the foundation. Furthermore, we can only meaningfully integrate biochemical knowledge if we know where the reactions take place, the physical distances that promote or inhibit a reaction, and the structural settings nature has provided for this purpose.

At present, we are witnessing a virtual explosion of knowledge about the signaling molecules cells use to communicate with each other during embryologic development and postnatal remodeling and healing. The same transcription and growth factors crop up time and again in relation to diverse tasks in different tissues and organs and at different phases of development. Table 4-1 presents a selection of these factors. Though research in the field of molecular developmental biology is very much in a state of flux, it seemed necessary to incorporate this aspect of structural development into this textbook, despite its potential to soon be outdated and deemed incorrect because of more recent findings. However, at least a fundamental understanding of molecular-oriented medicine has been established and is already being applied to some extent in dental and oral medicine on questions of bone formation, osseointegration of implants, and regeneration of the periodontium.

The more we intervene in the biology of the cell at the molecular level, however, the more side effects and difficult-to-manage repercussions come to light. Therefore, everyone who works in this area must act responsibly. The content of the individual chapters sometimes overlaps with that of other chapters, and in places cross references to other chapters are given. The chapters describing the individual structures in detail are preceded by a few introductory overview chapters.

Chapter 2 first explains the macroscopic anatomy of the mouth and its surrounding cranial structures and deals with orientation in the oral cavity. Each individual tooth is described here. Chapter 3 presents a brief assessment of the importance of evolutionary theory to explain the orofacial structures. Chapter 4, which explores general principles of morphogenesis, should be regarded as an introductory overview. Chapter 5 describes in detail the prenatal and postnatal development of the orofacial region. Tooth development is the subject of chapter 6. The reader will discover here that much more is known about the formation of the dental crown than about the formation of the roots. These gaps in knowledge are only partially filled by current research.

The structural makeup of dental enamel, dentin, root, and pulp is described in chapters 7, 8, and 9. Although dentin and pulp are structurally connected, each is assigned its own chapter because the structural similarity mainly relates to the odontoblasts as the outermost layer of the pulp and to the apposition of predentin as the innermost layer of dentin. Innervation of the dentin also involves a structural overlap with the pulp because the nerves extend from the pulp into the dentinal tubules and the content of the dentinal tubules may transmit stimuli from the periphery of the dentin into the pulp. Apart from these overlapping aspects, dentin and pulp are such different tissues that separate chapters were preferable. Chapter 10 is another introductory overview, dealing with the different structures of the periodontium that functionally form a unit, but they are discussed in their own chapters (chapters 11 to 13 on the cementum, periodontal ligament, and alveolar bone) because of their specific composition.

Chapter 14, concerning the oral mucosa, inevitably became a sizeable chapter; this shows how differently structured the various regions of the lining of the oral cavity are. The gingiva, as part of the marginal periodontium, is discussed in this chapter because it is part of the lining of the mouth. The salivary glands are given their own chapter, 15. Because the mouth region is an extensive opening of the body to the outside world, the immune system has particular importance in this region, as is reflected structurally in the tissues. This is why a detailed description of the immune system warrants its own chapter, 16. In chapter 17 on the development of the dentition and eruption of the teeth, aspects of tooth development are picked up again from chapter 6. However, because aspects of the periodontium, jawbone, and oral mucosa play roles in eruption of the teeth, it makes sense to describe these toward the end of the book. Chapter 18, about the temporomandibular joint (TMJ), stands alone in terms of the description of its structure, but in terms of its formation the TMJ can only be understood in connection with the development of the face. Functionally, it is closely connected to development of the dentition and occlusion, so this chapter usefully concludes the description of oral structural and developmental biology.

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