

MICROBIOLOGY IN CLINICAL DENTISTRY

Postgraduate Dental Handbook Series, Volume 13

Volume Editor

Frank J. Orland, DDS, SM, PhD

Series Editor

Alvin F. Gardner, DMD, MS, PhD

MICROBIOLOGY IN CLINICAL DENTISTRY

Frank J. Orland

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In recent decades there has been a gratifying increase of interest on the part of general practitioners of dentistry and dental specialists in new knowledge in the science and art of dentistry. Both biological and dental sciences are currently in a period of explosive growth, which has increased particularly in basic dental sciences with clinical applications and in clinical dentistry by diversification of experimental methods and dental procedures.

Dental sciences are considered multidimensional, and interdisciplinary variation is great. Dental scientists and practitioners know that the adaptation of techniques from other fields of science is complex, usually indirect, and unusable unless radically revised, extended, or reformulated for use in dentistry. Basic experimental methods originating in the clinical dental sciences may now be joined by the methods of the biological and physical sciences and made technically feasible by the introduction of modern electronics and computers.

Indeed, it is the primary goal of the *Postgraduate Dental Handbook Series* to present critical analyses based on impressive clinical and research experience accomplished by communication. This series is useful for both basic dental and clinical dental sciences. It likewise provides the most current concepts in clinical dentistry of direct value to dental practitioners, dental specialists, dental students, and dental hygienists throughout the world. By compiling all of our knowledge, the volumes in the *Postgraduate Dental Handbook Series* will fill a critical need felt by many dental clinicians and dental investigators.

Professor Frank J. Orland, at the Zoller Memorial Dental Clinic in the University of Chicago for some 40 years, presents this unique multiauthored monograph for the general practitioner and specialist in dentistry. Dr. Orland understands how to integrate individual writings into a unified treatise since he was editor of the *Journal of Dental Research* for nearly a dozen years. In this capacity he constantly read, edited, and rewrote the manuscripts. Concomitantly, Professor Orland was also Director of the Zoller Memorial Dental Clinic, a special center at the University of Chicago Hospitals and Clinics for research, teaching, and clinical practice. Recently, he has been writing historical monographs in the dental field. Moreover, at the University of Chicago these efforts have led to an appointment to the prestigious Fishbein Center for the Study of History of Science and Medicine.

As editor of this volume, Dr. Orland has chosen his contributors carefully in order to present the most advanced and current concepts in oral microbiology as related to clinical dentistry. His expert contributors have directed their discussions toward problems most

frequently encountered by the dental practitioner. The 13 chapters collectively allow the authors, men and women from diversified areas of dentistry, to assimilate ideas from the basic sciences and then apply them to their respective pertinent clinical areas. Dental practitioners who read this monograph will conclude that the editor and contributors have enlightened them on oral microbiological concepts and that the editor has accomplished a significant mission in this series.

Microbiology in Clinical Dentistry is a unique and welcome book that fills a gap between clinical dentistry and basic science, permitting rational treatment on a solid foundation of oral microbiology to great depth. This well-organized and excellent work represents a ready reference and broad guide to many modern dental practitioners' problems. It is presented in a succinct format, which should be easily understood by the general practitioner and will, therefore, assist him in meeting the new obligations of the profession of dentistry.

Thanks are due Professor Orland and the expert contributors of this review of oral microbiology in clinical dentistry for sharing with other dental practitioners their knowledge and experience. It should help all dentists in routine as well as unique treatment of their patients.

Alvin F. Gardner, Series Editor

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1 Introduction

Frank J. Orland

To be concerned with the microbiota of the oral cavity *per se* can be a fascinating endeavor. In this volume on *Microbiology in Clinical Dentistry*, however, considerable effort has been directed toward gleaning from basic science and clinical research new nuggets of knowledge useful for the concerned graduate dentist and his clinical team. Applicable information has been vividly presented by a dozen distinguished personalities expert in their respective fields. Certain parts of the book are prepared as a reference compendium. Other parts, bringing forth the latest facts and figures from the research laboratory and clinic, deal in detail with the newer concepts of oral disease produced by microorganisms.

OBJECTIVES OF BOOK

The primary objective of this volume is to emphasize the significance of microorganisms in oral health and disease, thereby

providing an analytical understanding leading to discernible diagnoses and effective treatment. A secondary objective is to impress the dental practitioner as well as the specialist with the means of prevention of such oral diseases. A tertiary objective is to teach the whole clinical team to avoid transmission of the pathogens to other patients, and to take precautions against contracting these infectious diseases themselves.

The objectives of each of the volumes in this postgraduate dental handbook series have an overall significance—namely, to transmit new fundamental information in a useful form for the general practitioner and the dental specialist. This has been emphasized in the Foreword of each volume by the Series Editor, Alvin Frederick Gardner. Moreover, it is through the commendable effort of the publisher, John Wright-PSG Inc., that this series has been made possible in a convenient format available to the dental health practitioners of the world.

EARLIEST MICROBIAL MANIFESTATIONS

Nearly everyone glancing at this book will be familiar with the anatomical and physiological aspects of the oral cavity. Patients and others should be aware of their mouths, since this special aperture has always been important to mankind. From antiquity onward, some efforts were made to describe function and malfunction of teeth and their contiguous surroundings among record-keeping man. However, existence of tiny living organisms on and in the human body, particularly within the oral cavity, was a concept not known nor really understood until recent times. This concept could only develop when scientific instruments and chemical means were developed to detect the presence of microorganisms and their by-products, some of which were found detrimental to important structures in the mouth such as the teeth.

Unknown to early observers, these microbic forms have been co-existing with the body-host as either parasites, saprophytes or commensals. With the human attribute to make order out of the seemingly chaotic state of nature, and as sharper and more analytical observations came about, investigators asked: How do such microorganisms fit into the classification that man has devised for other living things?

Historically, all such forms have been assigned to the Division Protophyta of the Plant Kingdom. Beyond this, they also have been put into the Procaryotae, especially those that are indifferent to light. More specifically the many microorganisms propagating in the oral cavity comprise such an array of creatures that they need to be visualized and described in depth throughout this treatise.

Since the majority are so tiny, it was not until microscopes became available that microbes actually could be seen by the human eye. Moreover, in recent times, with man's ingenuity, electronic means have been perfected to visualize even the most infinitesimal living entity. With these invaluable aids, the almost countless myriad of microorganisms multiplying in the mouth can be estimated and figuratively portrayed (Figure 1-1).

Microbes as such can be fascinating to observe, quite aside from what they do. This is especially so as one learns more and more about lesser and lesser creatures, ascertaining they can't really be as weird as described below by Hilaire Belloc in "The Microbe."*

The Microbe is so very small
 You cannot make him out at all,
 But many sanguine people hope
 To see him through a microscope.
 His jointed tongue that lies beneath
 A hundred curious rows of teeth;
 His seven tufted tails with lots
 Of lovely pink and purple spots,
 On each of which a pattern stands,
 Composed of forty separate bands;
 His eyebrows of a tender green;
 All these have never yet been seen—
 But Scientists, who ought to know,
 Assure us that they must be so. . . .
 Oh! let us never, never doubt
 What nobody is sure about!

On a more realistic level, it is feasible to describe pictorially the petite obligate parasite—the herpesvirus contrasted to the large, freely motile commensal—the entamoeba, as well as the spectrum of bacteria of various intermediate sizes and pathogenicity all flourishing in the mouth. Selected specimens of these fascinating creatures are highlighted in this first chapter (Figures 1-2, 1-3, 1-4, 1-5, 1-6).

EARLIEST MEN WITH INTERESTS IN MICROBES

As in any new field, once interest was established, many persons delved into microbiology and thrived even in the field of oral microbiology. Who were the two outstanding men one should honor as the first in this fertile field? By far the most notable ones are Antonj van Leeuwenhoek, clearly the first microbiologist (Figure 1-7), and

*From *Cautionary Verses*. By permission of Alfred A. Knopf, Inc., New York.

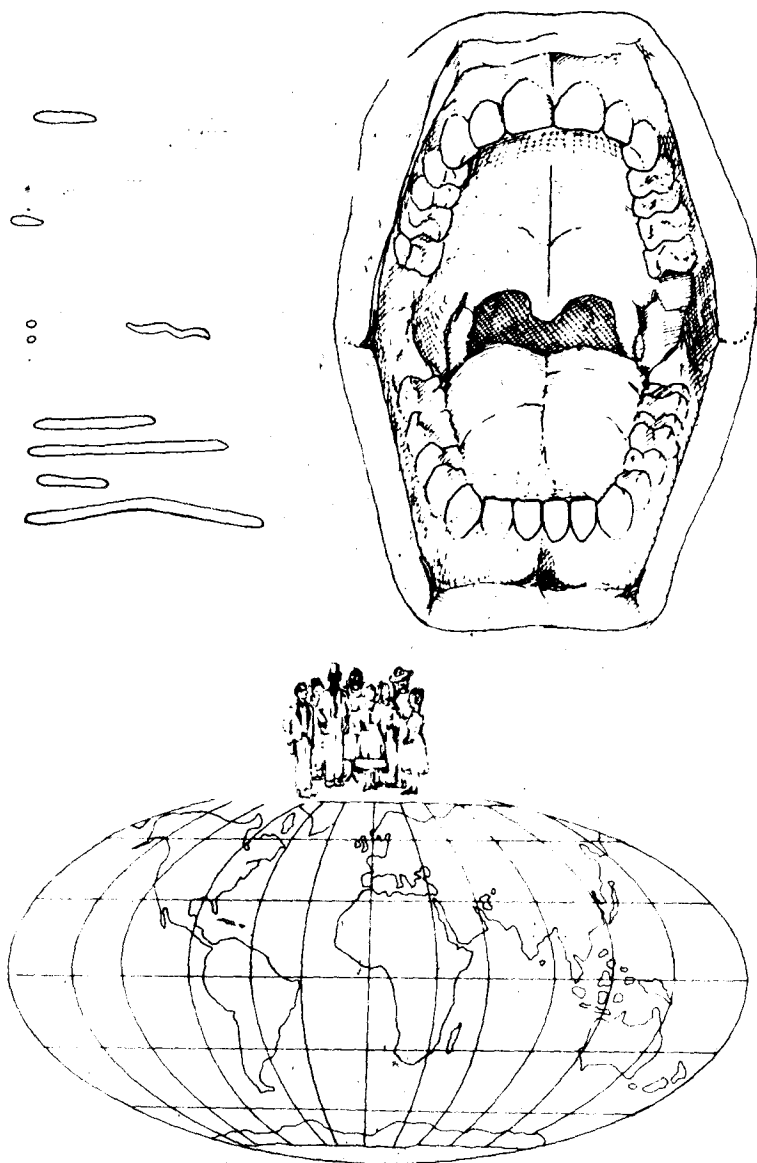


Figure 1-1 Some 300 years ago, upon viewing microbes of the mouth for the first time, Antonj van Leeuwenhoek exclaimed, "The number of these animalcules in the scurf of a man's teeth are so many that I believe they exceed the number of men in a kingdom." Portrayed (on left) are the drawings Leeuwenhoek himself made in 1683 of the mouth's microbic forms just as he saw them with his simple lenses. Currently, with the capability of visualizing electronically very much smaller microorganisms, one can now exclaim that in all probability there are as many microbic forms in the average human mouth as there are people on the face of the earth.

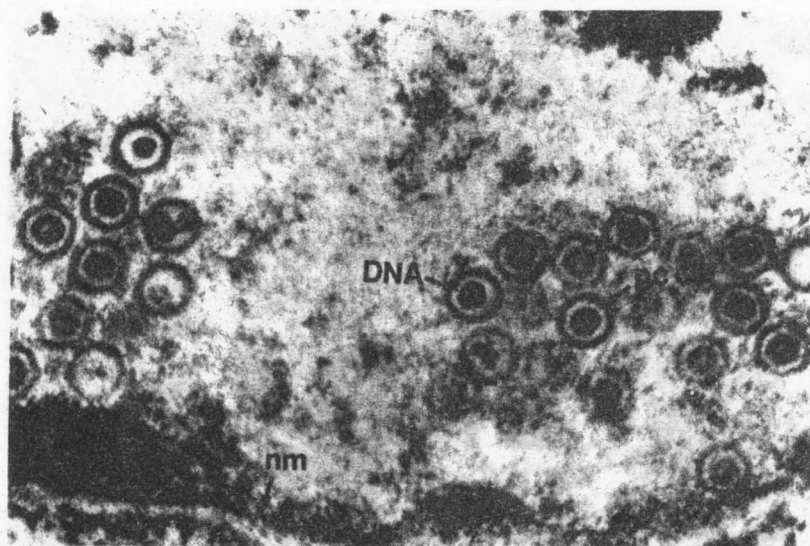


Figure 1-2 View inside oral epithelial cell nucleus, where the herpes simplex virus has multiplied. Nuclear membrane is at lower edge (nm). Each viral unit has a dense core of deoxyribonucleic acid (DNA) located at the very center. This is surrounded by a protein coat (pc), the capsid, which is mostly hexagonal in shape. Though the small herpesvirus resembles a sphere, in reality it is geometric—an icosahedron with 20 triangular faces and 12 corners. Thus, the herpes simplex virus is rather complex structurally, as revealed by the electron microscope (See Chaps. 5 and 6).

Willoughby D. Miller, whom one can justifiably designate as the first oral microbiologist (Figure 1-8).

Contributions of both these eminent microbiologists are elaborated on in Chapter 8. Moreover, since the central theme of this volume is microbiology as it pertains to *all* of dentistry, there are various unique areas covered by a dozen different microbiologists, each exhibiting knowledge in his or her field. All chapter authors present material gleaned from research including their own at their respective universities. Though each has written in an individual style, the editor has provided adherence to the central theme and main objectives of the book.

CHAPTER AUTHORS

The first chapter of substance is Chapter 2, on “Genetics of Microorganisms,” by Robert Kolstad. Genetics, as a new, significant

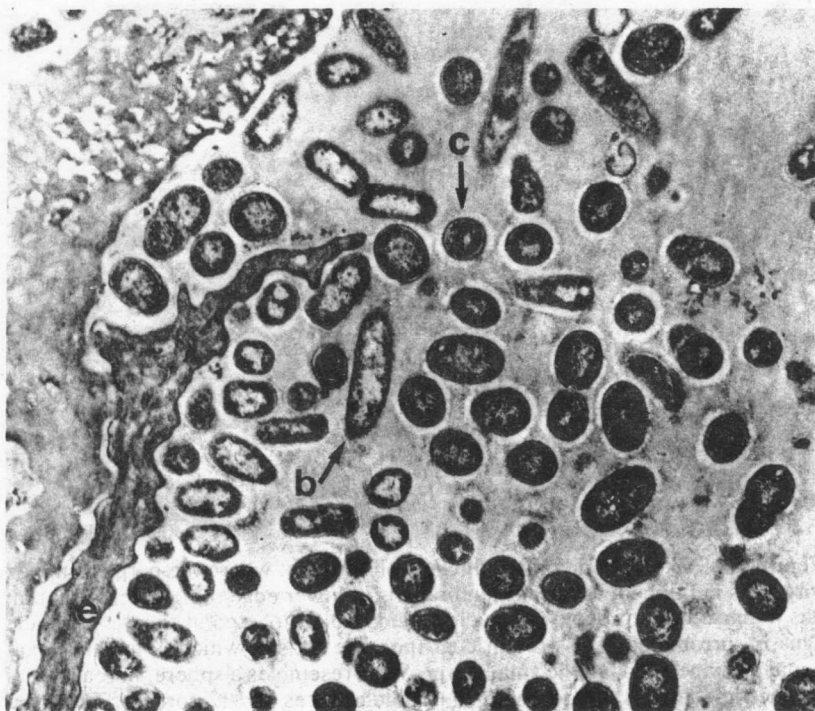


Figure 1-3 Thin-sectioned, greatly magnified dental plaque. Visible are a variety of coccal (c) as well as several bacillary forms (b) in this electron micrograph. Some internal structure is apparent within the microorganisms all situated in a polysaccharide matrix. Remnants of gingival epithelial cells (e) are on left (See Chaps. 5 and 8).

emerging area is clearly explained with ample diagrammatic illustrations of microorganisms. Dr. Kolstad has done considerable research and teaching in this field at the Baylor College of Dentistry where he has been an important member of the Department of Microbiology for several years, although originally from the University of Minnesota.

Chapter 3 deals with the role of "*Actinomyces* Cellular Macromolecules in Oral Disease" such as gingivitis and periodontitis. Dale Birdsell is an expert in the area of *Actinomyces*. In this chapter there is a profound discussion based on his recent research as well as that of his colleague, Werner Fischlschweiger. Their chapter provides an excellent evaluation of the role or roles of this microbic genus in gingivitis and periodontitis. In fact, it is so fundamental that it relates also to other oral microorganisms, their components and their by-products in activating host response systems relative to the specific pathological

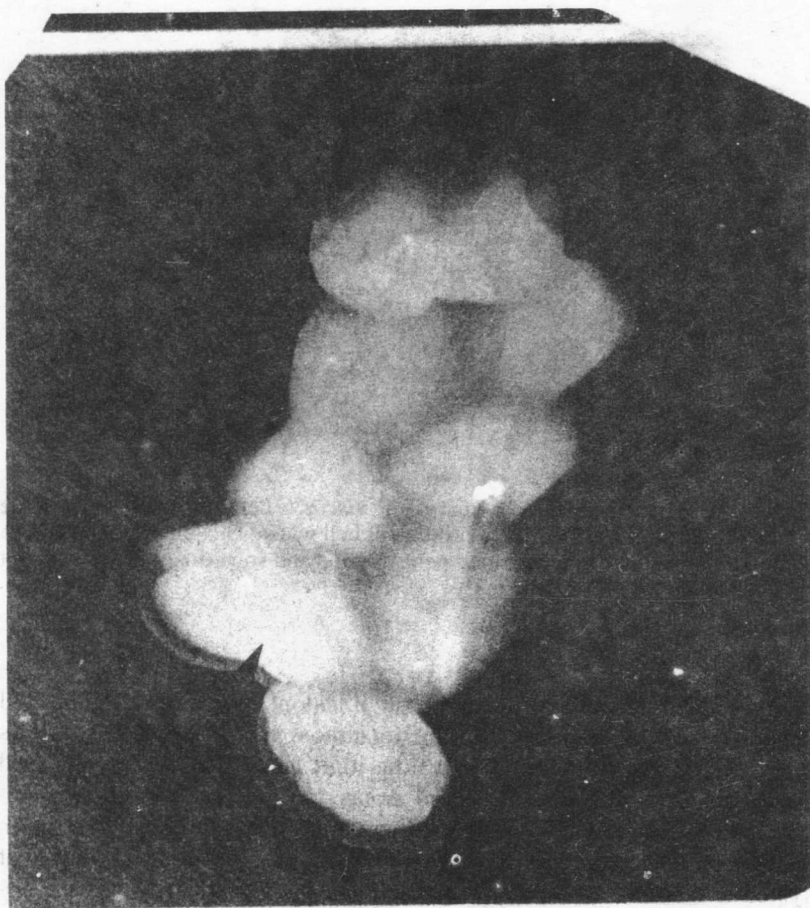


Figure 1-4 Electron micrograph of a microcolony of 9 (1 dividing to make 10) enterococci, the *Streptococcus* sp that in the early 1950s first produced extensive dental caries in the molars of rodents in the absence of all other bacteria within an otherwise germfree environment (See Chapter 8).

processes involved. This field is of importance to the clinician, and it may point the way to a basic comprehension and eventual prevention of these insidious diseases including root caries which also can be caused by these periodontopathogens propagated in dental plaque.

Chapter 4 presents an "Overview of Microbially Induced Oral Lesions." It provides a brief descriptive résumé of 73 different entities. Though many of these usually would be seen only in tropical lands,

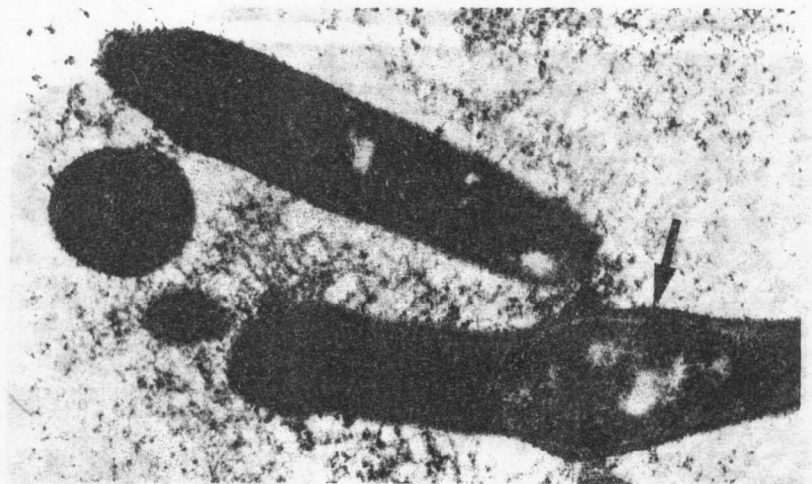


Figure 1-5 Greatly enlarged *Actinomyces viscosus* cells depicting some of the internal fine structures including prominent cell walls. This microorganism is a potential pathogen in gingivitis and periodontitis and sometimes a cause of root caries.

today with extensive world travel, such lesions of remote origin could appear in dental patients coming to almost any busy practitioner's office. Of all the innumerable lesions that can occur within the oral cavity and its immediate related areas, a high proportion are microbially induced. Thus, to clarify the common and the not so common lesions in the oral regions, both as entities or as manifestations of systemic disease, an extensive résumé has been provided in this chapter written by Frank J. Orland, the editor.

Chapter 5 deals in detail with the "Clinical Pathology of Oral Infections." In an elaborate table, there is an extensive compilation of the more common oral diseases by John P. Waterhouse. Originally from England where he received his education including fellowship in the Royal College in Pathology, he is now at the University of Illinois Medical Center, involved in many noteworthy capacities including oral pathology research and teaching.

Chapter 6 thoroughly covers the "Herpes Simplex Virus and Herpes Labialis." It was written by Charles Shipman, an outstanding virologist in the field of herpesvirus. Herpes labialis and its etiologic virus is a topic of which the dental practitioner should be aware and about which he should know more of its nature and modes of prevention of infection.

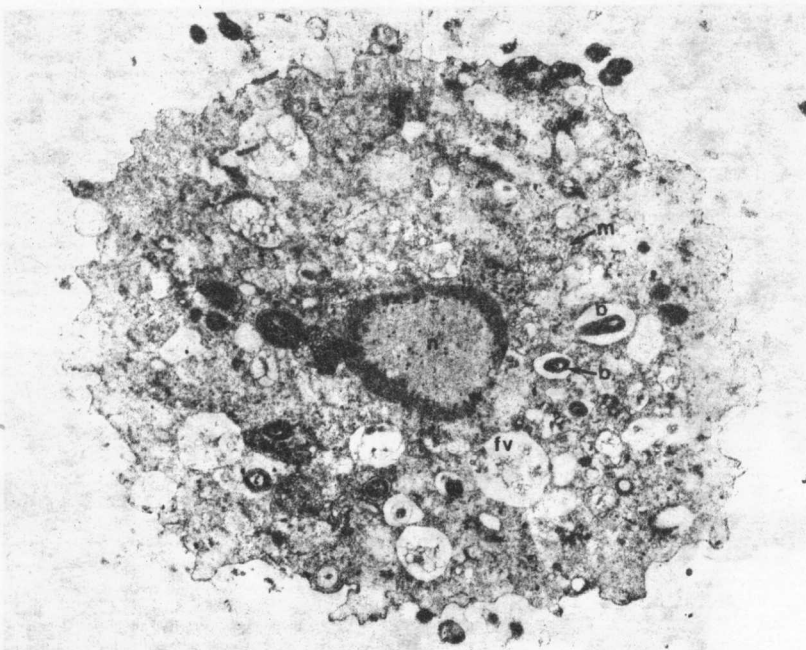


Figure 1-6 Cross-sectional view of *Entamoeba gingivalis*. Many internal ultrastructures are discernible in the electron micrograph: nucleus (n), food vacuole (fv), ingested bacteria (b) and mitochondria (m). This freely moving cell is found in the gingival crevices of normal and especially periodontally involved patients (See Chaps. 4 and 11).

Chapter 7 touches on some dramatic involvements of the dental practitioner, oral infections encountered in oral surgery. Historically, real advances were made in the art and science of oral surgery after two great achievements. One was the use of anesthetics as described in Volume 6 of this *Postgraduate Dental Handbook Series* by Gerald D. Allen, especially in his chapter on anesthesiology. The other was the control of infection. In this current volume, "Infections Encountered in Oral Surgery" was prepared by Dr. Roy Olson, a well-qualified oral surgeon who also has two master's degrees, one in oral surgery and the other in microbiology. Roy Olson comprehends and emphasizes the significance of microorganisms that can and still do cause extensive infections at the sites of oral surgery. He was formerly at the University of Chicago Hospitals and Clinics as chief oral surgeon.

Chapter 8 covers the historical aspects as well as current knowl-



Figure 1-7 Antonj van Leeuwenhoek, first microbiologist of the world (1632–1723), born and buried in Delft, The Netherlands. Photograph courtesy of the Rijksmuseum, Amsterdam, from original 1686 oil painting by Johannes Verkolje.

edge about that prevalent, if not the most prevalent, disease of mankind: caries. This chapter, entitled “Microbic Aspects of Dental Caries,” was prepared by Frank J. Orland who uses his university research and teaching experience for the reader’s edification.

Chapter 9 continues on the subject of “Ecology of Cariogenic Bacteria,” and provides a discussion on sugar metabolism with emphasis on one specific “cariopathogen.” This chapter by Charles Schachtele covers the important interactions of certain oral bacteria in