

ORAL MICROBIOLOGY AND INFECTIOUS DISEASE

*A Textbook for Students and Practitioners
of Dentistry*

BY

GEORGE W. BURNETT, B.A., M.A., D.D.S., Ph.D., F.A.C.D.,

*Lieutenant Colonel, Dental Corps, U. S. Army
Chief, Department of Dental Research,
Chairman, Department of Applied Sciences,
Dental Division,
Walter Reed Army Institute of Research,
Walter Reed Army Medical Center,
Washington*

AND

HENRY W. SCHERP, B.S., M.S., Ph.D.,

*Professor of Bacteriology and Immunochemistry, University
of Rochester, School of Medicine and Dentistry,
Rochester*



BALTIMORE

THE WILLIAMS & WILKINS COMPANY

1957

Copyright©, 1957
THE WILLIAMS & WILKINS COMPANY

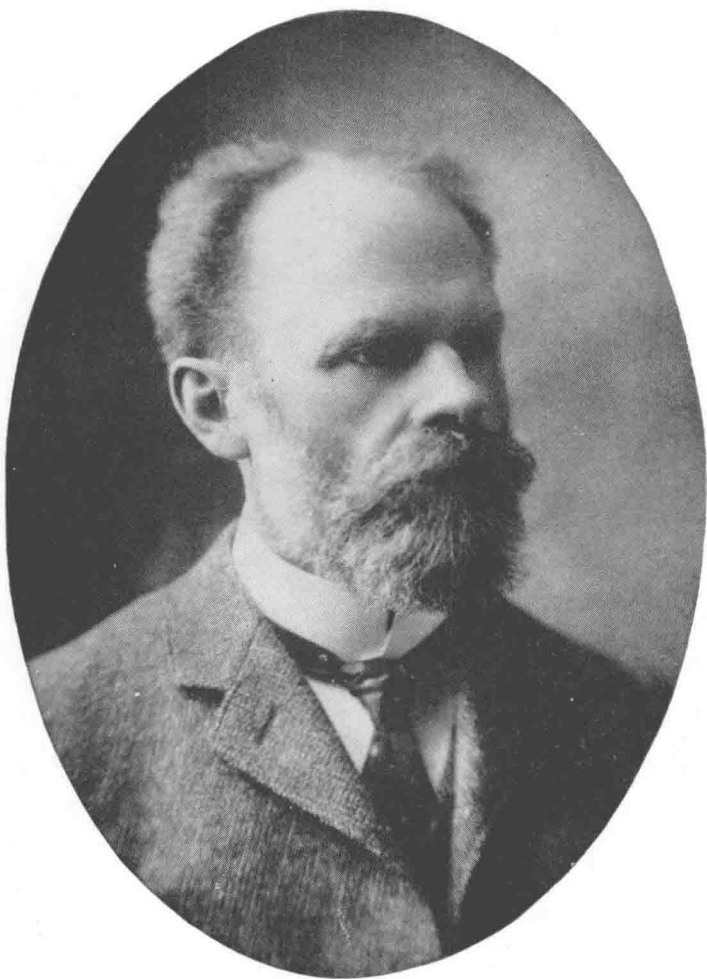
Made in the United States of America

Library of Congress
Catalog Card Number
57-7467

First Edition, 1957
Reprinted, 1958
Reprinted, 1959

COMPOSED AND PRINTED AT THE
WAVERLY PRESS, INC.
BALTIMORE 2, MD., U. S. A.

ORAL MICROBIOLOGY
AND
INFECTIOUS DISEASE



WILLOUGHBY D. MILLER, A.B., D.D.S., M.D., Ph.D., Sc.D., (1853-1907)

The father of oral microbiology. As the formulator of the chemico-parasitic theory of dental caries he was the first to apply a basic science to the solution of dental disease. Dr. Miller was a great leader as an investigator, practicing dentist, teacher, and prolific author in all phases of dentistry. He wrote the first comprehensive textbook of oral microbiology, *Die Mikroorganismen der Mundhöhle*, published in Germany in 1889 and in the United States in 1890 as *The Micro-Organisms of the Human Mouth*. (From School of Dentistry, University of Michigan.)

To the Memory of
WILLOUGHBY DAYTON MILLER
Founder of Oral Microbiology
His Concepts Have Never Been Superseded,
Only Amplified

PREFACE

The practice of dentistry in the maintenance of oral health depends on both the theory and practice of the science of microbiology. The task of presenting to the student of dentistry the principles of this science that are relevant to the practice of his profession offers an interesting challenge quite different from that confronting the writer of a treatise on medical microbiology for prospective physicians. Although the dentist requires at least as thorough an understanding of the interactions of microorganisms with the human body as does his confrère, the physician, his needs in this field differ in several significant ways. In the first place, the majority of the dentist's problems are concerned directly or indirectly with two of the most prevalent and important human diseases, dental caries and periodontitis, each of which has a peculiar relationship to microorganisms. In dental caries, microorganisms initially invade a tissue that is essentially nonreactive in the sense that the usual responses of inflammation, repair, and antibody formation are not evoked as they are in the infection of most other tissues. In periodontal disease, in which these reactions may be elicited, the microorganisms flourish superficially. Notwithstanding extensive research, in neither disease entity has it been possible to demonstrate unequivocally a specific relationship between the disease and a single causative agent, whether it be microbial or not. The concept of infectious disease as a neat correspondence of one microorganism to a specific group of symptoms is of course incomplete but it must be acknowledged that in many cases the control of one species of microorganism results in the control of the disease. In dental caries and periodontitis, however, the lesions contain a complex microbial flora which, to be sure, is quite often characteristic but in which no single variety of microorganism has been shown to predominate sufficiently to be designated as the specific etiological agent.

Consequently, in those diseases which pertain especially to dentistry, specific microbial diagnosis and therapy have as yet found little application. For the present, the dental practitioner must rely on such mechanical aids in treatment as débridement, restoration or prosthesis; on "shotgun" chemoprophylaxis and chemotherapy; and, perhaps most important of all, on the natural defenses of the body. As long as this condition persists, the dentist has less need than the physician for *systematic* microbiology. Perhaps it is this lack of an explicit *need* that accounts for the present state of systematic oral microbiology. Knowledge of the taxonomy and pathogenic potentialities of such important oral bacteria as lactobacilli, *Veillonella*, indifferent and anaerobic streptococci, spirochetes, vibrios, fusiform bacilli, actinomycetes, and other filamentous forms is still inadequate. Indeed, the systematists do not recognize many of the "species" of microorganisms referred to so frequently in dental literature. *Bergey's Manual of Determinative Bacteriology*, for example, lists many of them by name only in a limbo of appendices, usually without description. Important progress is being made, however, as more general microbiologists and students of disease are being attracted by the abundance of stimulating problems in this field.

Certain aspects of applied microbiology are more important to the dentist than to the physician. Almost all of the dentist's manipulations are made in an area of the body which is very heavily populated with microorganisms. The circumstances

are such that the application of a strictly aseptic technique is practically impossible in all but a few dental operations. Consequently, the dentist is more often directly and intimately concerned with the *practices* of disinfection, sterilization, and hygiene than is the general surgeon. Furthermore, the nature of the environment in which he must work necessitates that the dentist have a thorough understanding of the mechanisms of infectious disease, for, even when he does not deal with infected tissue, his every manipulation may introduce into the patient's body a multitude of microbes, many of which are known to cause serious systemic disorders. The dentist should have an ingrained comprehension and appreciation of the defensive processes that ordinarily make it possible for him to commit this outrage on the human body without an untoward reaction.

Despite the lack of exact information concerning many of the oral microorganisms, a wealth of significant material is available for a textbook intended to introduce to the student of dentistry those aspects of infectious disease that pertain to his profession. The present volume emphasizes the basic principles of microbiology as they relate to infectious disease and illustrates them freely by prototypical examples. It was planned as a compendium and not as an encyclopedic reference. Accordingly, we have intentionally omitted extensive bibliographies. However, the student who wishes to explore a specific topic in detail will find adequate documentation in the references cited at the end of each chapter. To all investigators whose results we have referred to without citation, we acknowledge our deep indebtedness.

We have integrated into this book, for the medical student and physician as well as for the dentist, that borderland of oral microbiology which comprises the oral manifestations of infections progressing primarily elsewhere and systemic infections originating in the oral cavity. If because of this material the present volume should be useful to the student of medicine also, its original purpose will thereby be enlarged to a gratifying degree.

The present endeavor could not have been completed without the generous cooperation of so many of our colleagues that individual acknowledgement is impossible. To all who contributed freely of time and advice in consultation, we offer sincere thanks. We are especially indebted to Brigadier General Arthur L. Irons, Doctor Herbert R. Morgan, and Colonel Thomas A. McFall for their continued support and encouragement. Although acknowledgement is made of the source of each text figure, a general expression of appreciation goes to all who so willingly contributed illustrations; thanks are due specifically to the Illustration Section of the Walter Reed Army Institute of Research and to the Medical Illustration Service of the Armed Forces Institute of Pathology.

Our deepest gratitude must go to our families for accepting cheerfully the degree of absenteeism that inevitably accompanies authorship.

Washington, D. C.
Rochester, N. Y.
June, 1956

GEORGE W. BURNETT
HENRY W. SCHERP

CONTENTS

Section I. The Origins, Development, and Scope of Microbiology

1. THE ORIGINS OF MICROBIOLOGY.	3
Historic Theories of Infectious Disease.	3
The Discovery of Microorganisms.	5
Additional Reading.	8
2. THE DEVELOPMENT OF MICROBIOLOGY.	9
The Germ Theory of Fermentation.	9
The Doctrine of Spontaneous Generation.	13
Additional Reading.	17
3. THE GERM THEORY OF DISEASE.	18
Additional Reading.	28
4. THE DEVELOPMENT OF ORAL MICROBIOLOGY.	29
Additional Reading.	33
5. THE SCOPE OF MICROBIOLOGY—A PERSPECTIVE.	34
The First Golden Age of Microbiology.	34
The Second Golden Age of Microbiology.	36

Section II. Systematic Microbiology

6. THE ISOLATION AND SYSTEMATIC EXAMINATION OF BACTERIA IN PURE CULTURE.	41
The Concept of Pure Culture and its Implications.	41
Methods for the Isolation of Pure Cultures.	42
The Maintenance of Cultures.	43
The Enumeration of Bacteria.	45
Selective Methods.	46
The Systematic Examination of Bacteria.	48
Additional Reading.	51
7. TAXONOMY.	52
Introduction.	52
Outline Classification of the Principal Bacterial Genera of Medical Importance.	54
Eumycetes (True Fungi).	57
Additional Reading.	59
8. BACTERIAL CYTOLOGY.	60
General Morphology.	60
Chemical Composition.	65
Physical Properties.	66
Staining.	67
Reproduction of Bacteria.	72
Additional Reading.	74
9. THE PHYSIOLOGY OF BACTERIA.	75
Introduction.	75
The Growth and Multiplication of Bacteria.	75
The Nutrition of Bacteria.	79
The Osmotic Barrier.	81
Physiology of Spores.	82

Variation and Adaptation.....	83
Interactions Between Microorganisms.....	86
Additional Reading.....	88
10. BACTERIAL METABOLISM.....	89
Unity Amid Diversity.....	89
Enzymology and Energetics.....	90
Carbohydrate Metabolism.....	93
Protein Metabolism.....	97
Nucleic Acid Metabolism.....	98
Enzyme Inhibition.....	99
Metabolism and Pathogenicity.....	100
Additional Reading.....	100
11. STERILIZATION.....	101
Introduction.....	101
Terminology.....	101
Physical Methods.....	103
Chemical Methods.....	107
Practical Aspects.....	112
Additional Reading.....	117
12. CHEMOTHERAPY.....	118
General Principles.....	118
Sulfonamides.....	120
Antibiotics.....	122
Problems and Prospects.....	127
Additional Reading.....	129
13. THE GENERAL PRINCIPLES OF VIROLOGY.....	130
Additional Reading.....	140

Section III. Infection and Resistance

14. INFECTIOUS DISEASE AS A BY-PRODUCT OF PARASITISM.....	143
Introduction.....	143
Multiple Determinants of Health and Disease.....	143
The Development of Parasitism.....	148
Additional Reading.....	152
15. THE NATURE OF VIRULENCE.....	153
Introduction.....	153
The Measurement of Virulence.....	154
Transmissibility and Life Cycles.....	155
Aggressive Activities of Parasites.....	157
Assessing the Significance of Microbial Factors.....	163
Additional Reading.....	164
16. INNATE OR NONACQUIRED BODILY DEFENSES.....	165
Introduction.....	165
The First Lines of Defense.....	165
The Clearing Mechanism of the Deeper Tissues.....	167
Factors that Modify Innate Resistance.....	172
Additional Reading.....	175
17. ACQUIRED BODY DEFENSES—ANTIBODIES AND ANTIGENS.....	176
Introduction.....	176

Basic Reactions of the Antibody-Forming Mechanism.....	180
The Nature of Antigenicity and Antigenic Specificity.....	184
The Nature of Antibodies and Antibody Specificity.....	189
Additional Reading.....	195
18. SEROLOGY.....	196
Introduction.....	196
One Antibody, Multiple Manifestations.....	196
Precipitation.....	197
Agglutination.....	199
Neutralization.....	201
Opsonization.....	202
Complement and its Reactions.....	203
Antigenic Analysis.....	206
Additional Reading.....	210
19. HYPERSENSITIVITY.....	212
Introduction.....	212
Anaphylaxis.....	215
The Tuberculin Type of Hypersensitivity.....	222
Hypersensitivity to Nonantigenic Substances.....	225
Microbial Hypersensitivity as a Factor in Pathogenesis and Immunity.....	226
Additional Reading.....	227

Section IV. Oral Infections

20. THE MICROBIAL FLORA OF THE ORAL CAVITY.....	231
The Acquisition of an Oral Microbiota.....	231
Problems Attending the Study of the Oral Microbial Flora.....	231
The Nature of the Oral Microbiota.....	233
Functional Groups of Microorganisms in the Oral Cavity.....	240
Regulation of the Oral Microbiota.....	241
The Relationship of Saliva to the Microbiology of the Oral Cavity.....	243
Additional Reading.....	249
21. THE GENERAL NATURE OF DENTAL CARIES.....	250
Introduction.....	250
Dental Caries in Prehistoric and Historic Man.....	250
The Nature of the Tooth.....	252
General Description of the Dental Carious Process.....	252
Factors Mediating Dental Caries.....	255
Additional Reading.....	257
22. HISTORICAL THEORIES OF THE ETIOLOGY OF DENTAL CARIES.....	258
Introduction.....	258
The Morphological Aspects of the Origin of Caries.....	258
Acids as a Cause of Dental Caries.....	258
Parasitic Etiology of Caries.....	259
The Chemico-Parasitic Theory of Miller.....	259
Additional Reading.....	263
23. THE MICROBIOLOGY OF DENTAL CARIES.....	264
The Case for Acidogenic Microorganisms.....	264
Lactobacilli as the Specific Etiological Agents of Dental Caries.....	265
Streptococci and Other Acidogenic and Aciduric Microorganisms in Dental Caries.....	271

Proteolytic Bacteria in Dental Caries	274
The Microbiota of the Dental Plaque and of Caries in Enamel and Dentin	277
Diet in Relation to the Microbiology of Dental Caries	280
Recapitulation	282
Additional Reading	282
24. APPLIED MICROBIOLOGY AND DENTAL CARIES	283
The Measurement of Dental Caries Activity by Bacteriological Methods	283
The Prevention and Control of Dental Caries	288
Additional Reading	297
25. PERIODONTAL DISEASE	298
Introduction	298
The Periodontium	298
The Development of the Periodontal Lesion	301
Classification and Nomenclature of Periodontal Disease	304
Parasitism and Periodontal Disease	305
Possible Interactions Between Bacteria and the Periodontium	308
Systemic Factors	312
General Consideration of Local Factors	315
Salivary Calculus	316
Gingivitis	318
Periodontitis	321
Acute Necrotizing Ulcerative Gingivitis (Vincent's Infection)	323
Herpetic Gingivostomatitis	324
The Relationship of Periodontal Disease to Focal Infection	324
Investigation of the Role of Bacteria in Periodontal Disease	325
Additional Reading	326
26. INFECTIONS OF THE TOOTH PULP AND PERIAPICAL TISSUES	327
The Tooth Pulp and the Periapical Tissues	327
The Clinical Course of Pulpal and Periapical Disturbances	329
The Etiology of Pulpal and Periapical Disturbances	332
Complications of Pulpal and Periapical Infections	335
The Role of Bacteriological Control in the Treatment of Pulpal and Periapical Infection	337
Additional Reading	339
27. SYSTEMIC BACTERIAL AND PROTOZOAN DISEASES WITH ORAL MANIFESTATIONS	340
Introduction	340
Syphilis	340
Tuberculosis	345
Anthrax	347
Tularemia	348
Gonococcal Infection	349
Diphtheria	350
Leprosy	350
Leishmaniasis (Kala-Azar)	350
Yaws	352
Additional Reading	352
28. VIRAL AND RICKETTSIAL DISEASES WITH ORAL MANIFESTATIONS	353
Herpes Simplex	353
Herpes Zoster (Shingles)	356

Varicella (Chicken Pox)	357
Mumps	357
Foot and Mouth Disease in Man	358
Lymphogranuloma Venereum	359
Diseases Associated with the Coxsackie Viruses	360
Rickettsialpox	361
Measles	362
Smallpox	363
Additional Reading	364
29. MYCOTIC DISEASES WITH ORAL MANIFESTATIONS	365
Actinomycosis	365
Moniliasis	369
Histoplasmosis	372
Sporotrichosis	373
Geotrichosis	376
South American Blastomycosis	377
Additional Reading	378
Section V. Infectious Diseases	
30. MICROCOCCI AND MICROCOCCAL INFECTIONS	381
Introduction	381
Cultivation and Nutrition	381
Biochemical and Physiological Activities	382
Pathogenic Qualities of Micrococci	384
Micrococcal Infections	386
Systemic Defenses Against Micrococcal Infection	387
Chemotherapy in Relation to the Micrococci	388
Gaffky Tetragen	388
Additional Reading	388
31. STREPTOCOCCI AND STREPTOCOCCAL INFECTIONS	389
Introduction	389
Cultivation and Nutrition	390
Biochemical and Physiological Activities	392
Streptococcal Infections	397
Additional Reading	402
32. PNEUMOCOCCI AND PNEUMOCOCCAL INFECTIONS	403
Introduction	403
Nutrition and Cultivation	403
Physiological and Biochemical Activities	404
Epidemiology and Pathogenicity	406
Pneumococcus Infection	406
Additional Reading	408
33. PATHOGENIC GRAM NEGATIVE COCCI	409
Introduction	409
The Gonococci	409
Gonococcal Infection	410
The Meningococci	411
Meningococcal Infection	412
Additional Reading	414

34. THE DIPHTHERIA BACILLUS.....	415
Bacteriology of <i>Corynebacterium diphtheriae</i>	415
Diphtheritic Infections.....	416
Additional Reading.....	420
35. MYCOBACTERIUM.....	421
Introduction.....	421
<i>Mycobacterium tuberculosis</i>	421
Tuberculosis.....	423
Leprosy.....	427
Additional Reading.....	428
36. PASTEURELLA.....	429
Introduction.....	429
<i>Pasteurella pestis</i> , the Cause of Plague.....	429
<i>Pasteurella tularensis</i> , the Cause of Tularemia.....	432
<i>Pasteurella multocida</i> , the Cause of Hemorrhagic Septicemia.....	434
<i>Pasteurella pseudotuberculosis</i>	434
Additional Reading.....	435
37. BRUCELLA AND BRUCELLOSIS.....	436
Introduction.....	436
Bacteriology of Brucella.....	436
Brucellosis.....	437
Additional Reading.....	438
38. THE HEMOPHILIC BACTERIA.....	439
Introduction.....	439
<i>Hemophilus influenzae</i>	439
<i>Hemophilus pertussis</i>	441
<i>Hemophilus ducreyi</i>	442
Additional Reading.....	442
39. ENTEROBACTERIACEAE.....	444
Introduction.....	444
The Coliform Bacilli.....	446
The Salmonella.....	449
The Shigella.....	454
Dysentery.....	456
Additional Reading.....	457
40. CLOSTRIDIUM.....	459
Introduction.....	459
<i>Clostridium tetani</i> and Tetanus.....	460
Gas Gangrene.....	462
<i>Clostridium botulinum</i> and Botulism.....	464
Additional Reading.....	465
41. THE VIBRIOS.....	466
Introduction.....	466
Bacteriological Characteristics of <i>Vibrio comma</i>	466
Cholera.....	468
Vibrios Related to <i>Vibrio comma</i>	469
Additional Reading.....	469
42. SPIROCHETES.....	470
Introduction.....	470

<i>Treponema pallidum</i> , the Causative Agent of Syphilis.....	471
<i>Treponema pertenue</i> , the Causative Agent of Yaws.....	475
<i>Treponema caraleum</i> , the Causative Agent of Pinta.....	476
The Leptospirae and Leptospiroses.....	478
<i>Borrelia recurrentis</i> and the Spiral Microorganisms Associated with Relapsing Fever..	480
The Oral Spirochetes.....	482
Additional Reading.....	487
43. TRANSITIONAL GROUPS OF BACTERIA.....	489
The Pleuropneumonia Group.....	489
<i>Streptobacillus moniliformis</i>	493
The Bartonella Group.....	494
Additional Reading.....	494
44. VIRAL AND RICKETTSIAL DISEASES.....	495
General Characteristics of Viral and Rickettsial Diseases.....	495
The Classification of Viral and Rickettsial Diseases.....	496
Viral Diseases Involving Integument or Mucous Membranes.....	497
General Catarrhal and Respiratory Viral Diseases.....	498
Viral Diseases Characterized by Invasion of the Central Nervous System.....	502
Viral Diseases Characterized by Being Transferred to Man by Arthropod Vectors...	506
Viral Exanthemata.....	508
Viral Hepatic Diseases.....	508
Viral Eye Diseases.....	509
Rickettsial Diseases.....	510
Additional Reading.....	513
45. PROTOZOA AND PROTOZOAN INFECTIONS.....	514
Introduction.....	514
Classification of Protozoa.....	515
The Alimentary Canal Amebae and Ciliates.....	516
Blood and Tissue Flagellates.....	519
Alimentary Canal and Urogenital Flagellates.....	522
The Malaria Parasites of Man.....	523
Additional Reading.....	527
46. MYCOTIC INFECTIONS.....	528
Introduction.....	528
The Dermatomycoses.....	528
Systemic Mycotic Diseases.....	531
Additional Reading.....	539

I

THE ORIGINS, DEVELOPMENT, AND SCOPE OF MICROBIOLOGY

