AN ATLAS OF DENTAL HISTOLOGY

By

E. B. MANLEY

M.Sc., B.D.S., F.D.S., R.C.S. (Eng.)

Professor of Dental Pathology, University of Birmingham

E. B. BRAIN

B.Sc., F.I.B.P., F.R.P.S.

Lecturer in Dental Histology, University of Birmingham

AND

E. A. MARSLAND

Ph.D., B.D.S., L.D.S., R.C.S. (Eng.)

Lecturer in Dental Pathology, University of Birmingham

BLACKWELL
SCIENTIFIC PUBLICATIONS
OXFORD

Published simultaneously in the United States of America by Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Illinois.

Published simultaneously in Canada by the Ryerson Press, Queen Street West, Toronto, 2.

First printed, October, 1947
Second Edition, Revised, 1955

Printed in Great Britain for Blackwell Scientific Publications, Ltd.
by A. R. Mowbray & Co. Limited in the City of Oxford
and bound at the Kemp Hall Bindery

INTRODUCTION TO THE SECOND EDITION

SINCE this Atlas was first published there have been many requests from colleagues for the inclusion of a limited amount of text if a further edition was contemplated. In our endeavour to fulfil these requests we found that the limitation of text is not without risk. What to omit and what to stress in a subject, many aspects of which are still controversial, constitutes a serious problem. An attempt has been made to reveal only fundamentals, and the student is still required to refer to standard works whose fuller text deals with those aspects of the subject beyond the scope of this Atlas, which retains its ascribed function as a support for lectures.

In the first edition a general reduction in the size of the illustrations had to be carried out, with the result that magnification of many of the photomicrographs was lower than intended. As far as possible this has now been rectified. The arrangement of the illustrations has been completely revised and their number considerably increased.

In order that a knowledge of the development and structure of the enamel should be as complete as possible an entirely new section on amelogenesis has been added.

In the technical section a new method for the preparation of decalcified serial paraffin sections of mature enamel has been included. A description of more advanced techniques involving micro-dissection and the use of phase contrast microscopy and incident light microscopy have been omitted as they are used mostly in the field of research and are not generally available to the student in the classroom. These techniques have greatly extended our knowledge of the dental tissues and it is hoped that the student will read the literature which deals specially with these recent advances.

Finally, we wish to thank Professor A. E. W. Miles for reading the text and contributing so many helpful suggestions. We are indebted to Mr. C. Lees and Mr. G. A. Johnson for their valuable technical work in the preparation of the sections and photomicrographs and to Miss A. M. Gartland for her patience and care in the preparation of the manuscript. Once again we wish to thank the Publishers for their courtesy and consideration and for accepting all the additional illustrations.

E. B. M.
E. B. B.
E. A. M.

INTRODUCTION TO THE FIRST EDITION

DR. A. W. WELLINGS devoted the greater part of his life to the study of the normal structure and functions of the dental tissues. He believed that visual education was the greatest medium through which students could be taught, and his great desire was to produce an Atlas of Dental Histology. Unfortunately, this desire was not to be fulfilled by him as he died in August, 1945, but the present authors have taken up the task in the hope that the same object will be achieved.

In the mythological sense the word 'Atlas' signifies support, and it is this function that should be ascribed to this book—a support for lectures.

The time allotted to the dental student for microscopy is inadequate and may consist only in the period allocated to him in the class. As the pressure of work in other subjects limits his time in the laboratory, further study can be carried on at home with the aid of illustrations. It is intended, therefore, that this Atlas should be used not only in the laboratory when sections are being examined, but also for reference during the student's reading hours when no microscope is available.

The aim in the production of photomicrographs for teaching purposes is to obtain perfect detail throughout, and in dealing with the complex structure of the dental tissues, it is believed that this can best be achieved by the use of black and white illustrations. While colour transparencies have almost entirely superseded black and white in clinical photography, the exclusive use of colour reproductions in photomicrography is not yet practicable, since in a series of sections given out to the class, staining reactions vary considerably in shades of colour.

As far as possible, an attempt has been made to produce photographs illustrating the structures which the student himself will see under the microscope. There must, of course, be exceptions, and some illustrations will show structures which the student may not see in the practical class. For example, it is extremely difficult to provide any large class with sections which show the nature of Nasmyth's membrane. Nasmyth's membrane or enamel cuticle is one of our controversial problems, but the illustrations given have been chosen with the object of showing clearly that there is a definite pellicle with a cellular layer superimposed. The latter is quickly worn off the masticating surface of the clinical crown of a tooth after eruption, exposing the true pellicle, while below the clinical crown, the cellular layer plays a part in establishing the attachment of the oral epithelium to the enamel surface of the tooth.

Structure has been dealt with before development as it is the first subject with which the student is likely to be confronted.

One criticism on the wide range of enlargement employed may perhaps be anticipated. The eyepieces of the microscope, of course, give standard magnifications, but in photomicrography, each slide has an optimum enlargement which yields the sharpest definition of the chosen field, and it is for the sake of the latter that uniformity of magnification has been sacrificed.

The section on histological technique has been included in order to give students a brief outline of the principles involved and methods used in the preparation of the dental tissues for microscopical examination. The few methods described in detail are those used in the Department of Histopathology of the Birmingham University Dental School, and are modifications of standard methods specially adapted for use on the dental tissues and which have been found satisfactory.

The object of this section is twofold. First, to fulfil the requirements of the Dental Education and Examination Committee of the General Medical Council, and second, to offer the student a choice from the number of methods given to him by standard text books on the subject. These, however, should be used for reference when further details are required, especially with regard to fixation and staining.

It is not suggested, nor indeed is it possible, that a student in the short time at his disposal should become an expert technician, but he should possess sufficient technical knowledge to enable him to appreciate the special difficulties involved in the preparation of the hard and soft dental tissues for histological examination. He must learn to distinguish true histological appearances from those of artefacts in order that he may interpret his findings correctly. This is of vital importance to a student who wishes to undertake research. The number of reagents and prolonged treatment to which the dental tissues have to be submitted can produce artefacts which may prove pitfalls for the unwary.

Finally, it is hoped that this section will help to stimulate the student's interest, for even the improved methods of to-day fall far short of our requirements and there is a great need for research in the technical field of Dental Histology.

We wish to thank Dr. Lilian Lindsay for her many helpful suggestions and kindly criticism, and to acknowledge our indebtedness to Mr. C. Lees and other members of our technical staff for their valuable team work in the preparation of the sections. Our thanks are particularly due to the Publishers for the interest they have taken in the problems of production.

E. B. M.
E. B. B.

CONTENTS

AN ATLAS OF DENTAL HISTOLOGY

ENAMEL

Enamel is the hardest tissue of the body. It covers the crowns of teeth in man and most other mammals, forming a wear-resisting surface for the comminution of food. The essential structural units of the enamel are highly calcified columns or rods called the enamel prisms which are surrounded by an organic prism sheath and bound to one another by an inorganic cementing substance. This is known as the interprismatic substance which varies in amount in different parts of the enamel and in some cases appears to be absent.

The enamel prisms pass from the amelo-dentinal junction to the surface and as a rule pursue an undulating course. They tend to be grouped into bundles which interweave to some extent, and this arrangement confers strength to the tissue. In the region of the cusps of premolar and molar teeth, where the enamel is subjected to considerable stress, the interweaving of groups of prisms is pronounced and this is known as gnarled enamel.

Reference must be made to a delicate organic matrix which runs continuously throughout the enamel prisms and interprismatic substance. It is, however, so fragile and so closely bound up with the inorganic component of the tissue that its recovery entails special and exacting techniques, a description of which is beyond the scope of this work.

The Hunter-Schreger Bands

When longitudinal ground sections of enamel are examined by incident illumination, alternate light and dark bands of varying width can be seen passing outwards from the amelo-dentinal junction almost to the surface. This appearance is due to a regular change in direction of groups of prisms, the optical character of which differs according to whether they are cut longitudinally or transversely. Incident light is reflected from the ends of transversely cut prisms which consequently appear as light bands in contrast to the longitudinally cut prisms which absorb the incident light and appear dark. The fact that this optical phenomenon of Schreger's bands, seen in ground sections, is produced by alternate bands of longitudinally and transversely cut prisms can be verified by the examination of decalcified sections of developing enamel.

Incremental Lines

Brown Striae of Retzius and Cross Striation of Enamel Prisms

Enamel is laid down originally as an organic matrix which is deposited in layers and, in common with most other growth mechanisms, the process is intermittent, periods of active formation alternating with periods of rest. The regular interruptions in the development of the enamel are responsible for the characteristic pigmented lines known as the Brown Striae of Retzius which mark the junction between successive incremental layers of the tissue.

In addition to this gross incremental pattern there is a finer growth pattern of delicate cross striations seen in individual prisms. The interior of each prism is divided into a series of units produced by the activity of the enamel-forming cells. The junctions between successive units are represented by fine striations.

Organic Elements of Enamel

In addition to the prism sheaths other organic elements can be demonstrated in enamel. These are the enamel lamellae, enamel tufts and enamel spindles.

Enamel Lamellae

Lamellae may be described as thin leaf-like organic structures which pass through the complete thickness of the enamel. In transverse section seen under low magnification they appear as narrow tracts of organic material extending from the enamel-dentine junction to the surface of the tooth. They can be demonstrated in the enamel of unerupted teeth, and therefore must be regarded as normal elements of the tissue. Under high magnification they are seen to be continuous with the surrounding prism sheaths (Plate 13).

In longitudinal sections lamellae can be identified only by experimental decalcification when their distribution as thin leaf-like structures extending from the cervical region towards the crown surface can be seen (Plate 11).

Enamel Tufts

Enamel tufts are organic structures seen only in transverse sections. They arise at the amelo-dentinal junction and traverse the enamel for about one-third of its thickness. They are acid-resistant structures, and decalcified sections of mature enamel show them to be intimately related to the prism sheaths. They are the result of a failure of calcification and local collapse of prisms and interprismatic substance. Under high magnification they appear as single organic strands running in the same direction as the prisms. Under low magnification several strands running in different directions at various levels of the enamel are projected into one plane and the characteristic tuft-like appearance in transverse ground sections is produced.

Enamel Spindles

These structures are dilated ends of dentinal tubules which have crossed the amelo-dentinal junction during the first stages of dentine and enamel formation. They can be seen in longitudinal ground sections immediately over the dentine cusps, and at right angles to the dentine surface.

The Neo-Natal Line

The enamel of deciduous teeth is similar in structure to that of the permanent teeth. One additional feature of deciduous enamel of particular interest is the neo-natal line which is an accentuated incremental line. It is due to a temporary disturbance in the development of the enamel produced by the altered physiological environment associated with birth. The neo-natal line marks the junction of pre-natal and post-natal enamel.

Finally, the student must realize that the microscopic study of such a highly calcified structure as enamel has always been one of great technical difficulty. It is only by the correlation of results obtained by the use of different techniques that our present knowledge of this tissue has been built up. The two principal methods used are: (1) the preparation and study of ground sections or ground surfaces; (2) the preparation and study of decalcified material.

(1) The chief advantage of ground sections is that the relationship between various structures remains undisturbed. Their use is, however, limited by their comparative thickness which interferes with the transmission of light and may produce misleading appearances. Ground surfaces examined by incident light may be used in conjunction with ground sections. The value of both these methods may be increased by the technique of etching with dilute acids when slight decalcification of the surface causes the organic elements to be brought into sharp relief. By the use of Van Gieson's stain, which contains picric acid, both etching and staining can be carried out in one operation.

(2) In the second group serial paraffin sections of decalcified developing enamel are particularly useful. Their value lies in the fact that the organic matrix laid down in the early stages of tooth development has the prism structure of the mature tissue. Decalcification of the matrix of developing

enamel, which contains only a small proportion of inorganic elements, enables thin sections of the retained tissue to be cut and stained.

More recently a method has been evolved for the preparation of decalcified serial sections of fully formed mature enamel. This method has been adapted to show the distribution of the organic elements of enamel, and is described in detail in the technical section.

ENAMEL

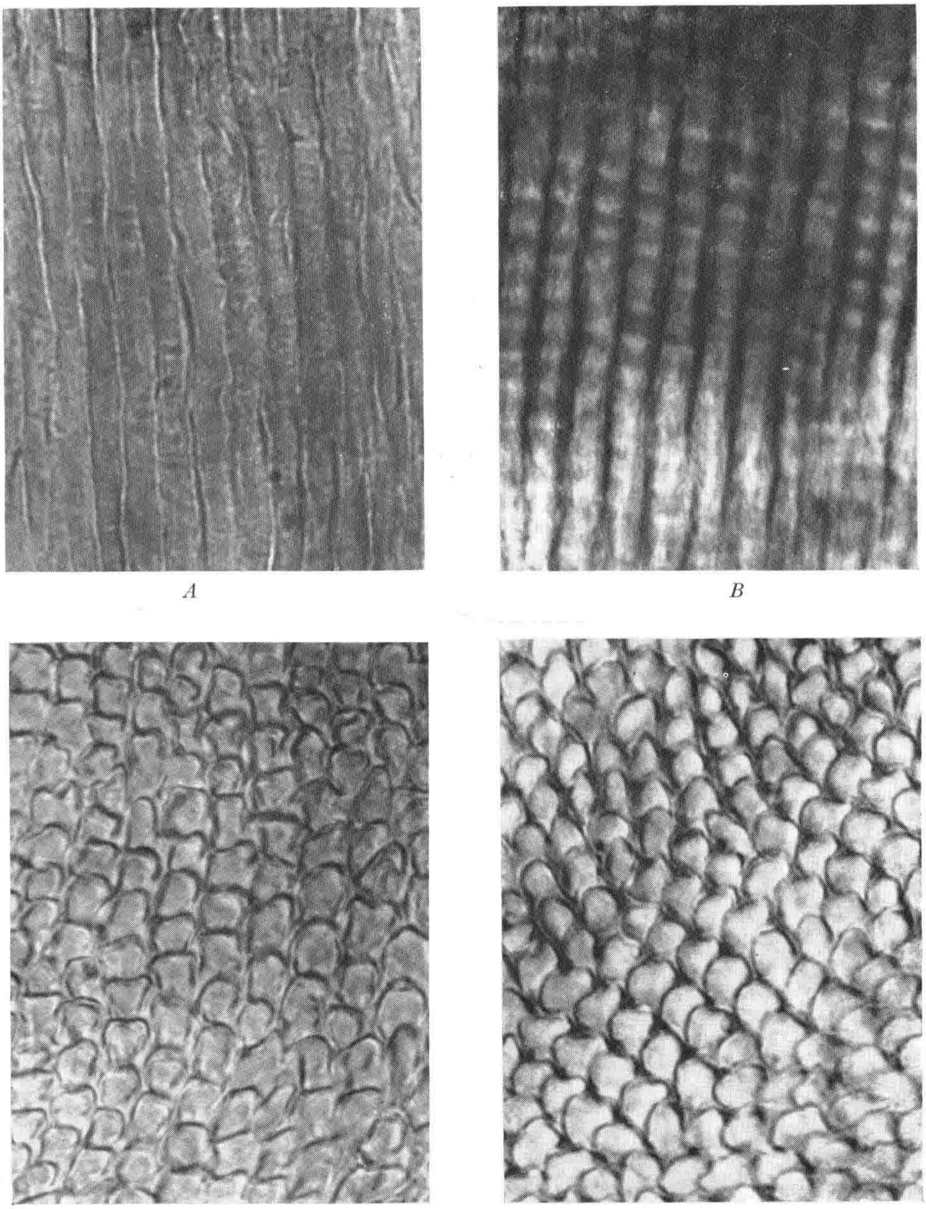
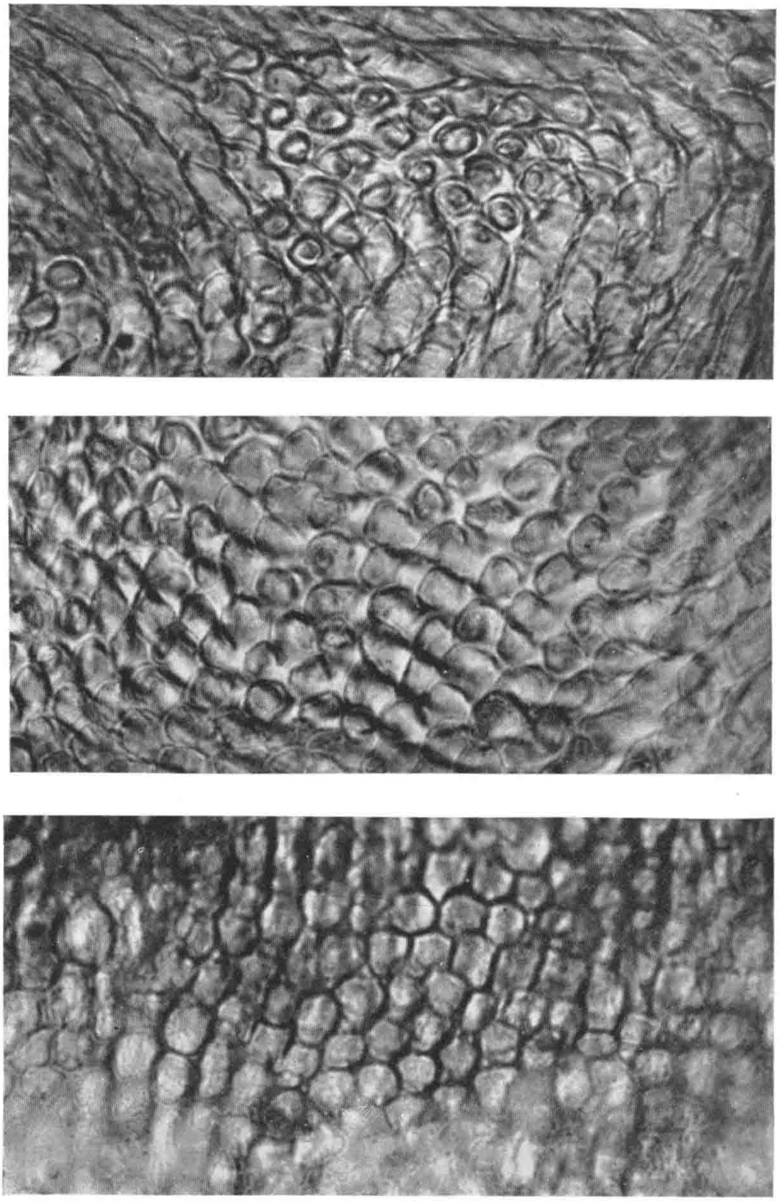


PLATE I

GENERAL STRUCTURE OF MATURE ENAMEL

Enamel prisms seen under high magnification (× 1070)
A—Longitudinal prisms. Ground section.
B—Longitudinal prisms. Decalcified section, stained with methyl blue.
C—Transverse prisms. Etched ground section.
D—Transverse prisms. Decalcified section, stained with methyl blue.



A

B

C

PLATE 2

SHAPE OF ENAMEL PRISMS

Decalcified sections of young enamel.

Magnification × 1070.

A—Round prisms seen in an abundance of interprismatic substance over dentine cusp.

B—Scale-like appearance of prisms cut obliquely.

C—Group of almost hexagonal shaped prisms running parallel to one another and cut transversely.

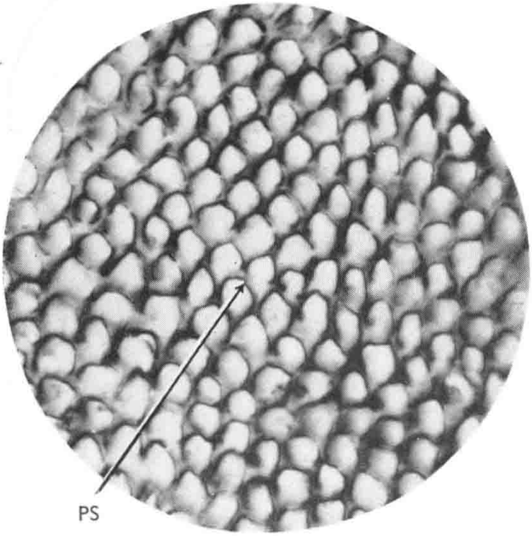


PLATE 3

PRISM SHEATHS

Decalcified section of mature enamel.

Magnification × 1000.

A transverse section of enamel prisms, interprismatic substance and prism sheaths (*PS*)

Stained with Weigert's Iron Haematoxylin.

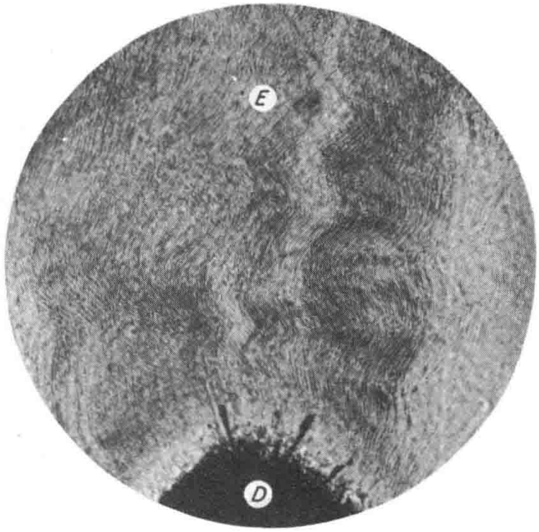


PLATE 4

GNARLED ENAMEL

Longitudinal ground section.

Magnification × 90.

D—Dentine cusp. *E*—Enamel.

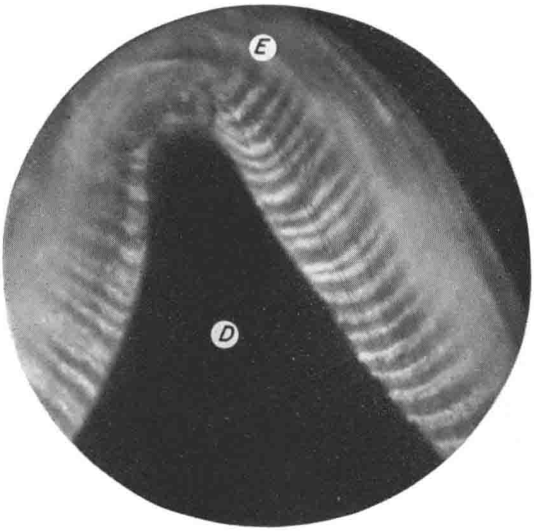


PLATE 5

SHREGER'S LINES

Longitudinal ground section seen by reflected light showing the optical phenomenon of Shreger's lines. It should be noted that the alternate light and dark bands conform to the distribution of transverse and longitudinal prisms which are illustrated in Plate 6.

Magnification × 25.

E—Enamel. *D*—Dentine.

PLATE 6

SHREGER'S LINES

Decalcified section of young enamel showing alternate groups of transversely and longitudinally cut prisms.

Magnification × 155.

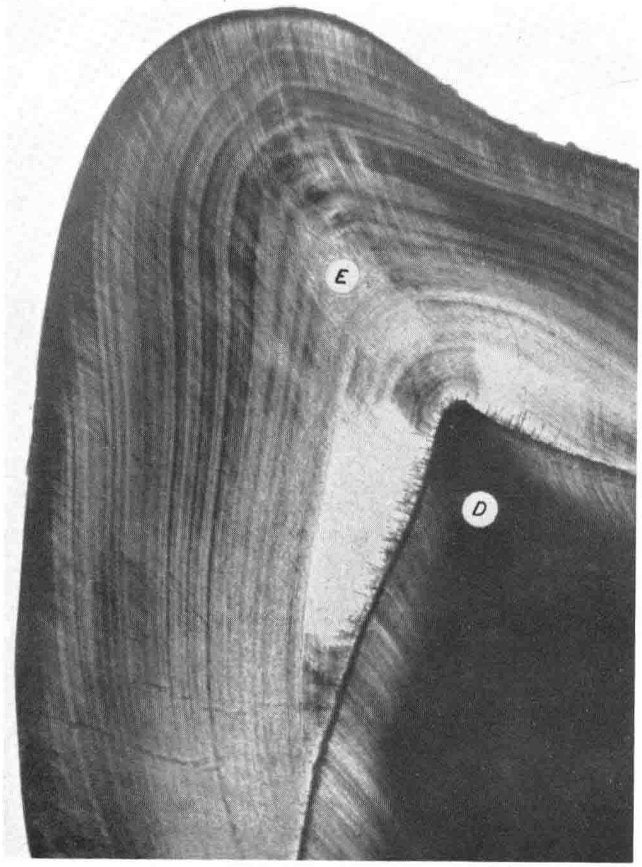


PLATE 7
BROWN STRIAE OF RETZIUS
Longitudinal ground section through upper molar.
Magnification × 30.
E—Enamel with Retzius lines.
D—Dentine.

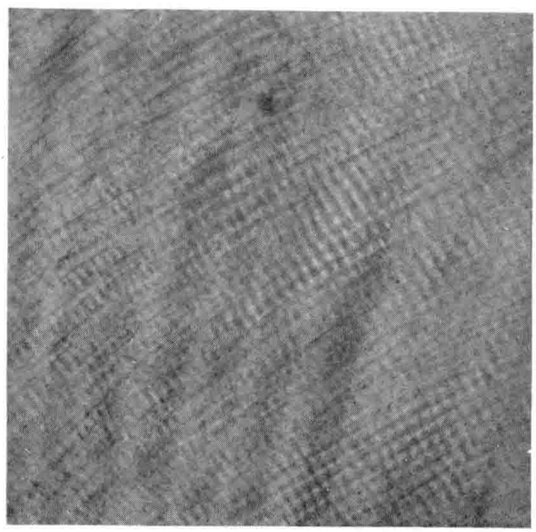


PLATE 8
CROSS STRIATION OF ENAMEL PRISMS
Longitudinal ground section of Enamel.
Magnification × 420.

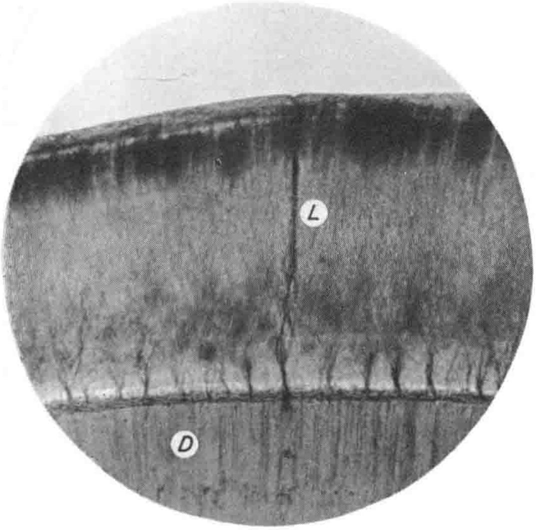


PLATE 9

ENAMEL LAMELLA

Transverse ground section.

Magnification × 35.

L—Lamella extending from the surface of the enamel to the dentine (*D*).

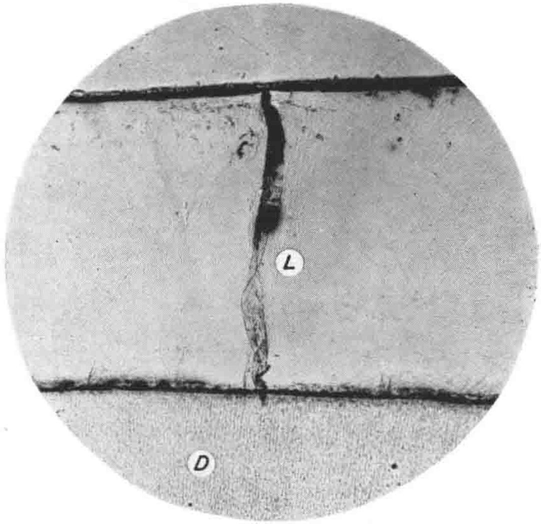


PLATE 10

ORGANIC NATURE OF ENAMEL LAMELLA

Transverse ground section of an unerupted tooth, stained by silver nitrate and decalcified on the stage of the microscope. The calcified enamel has been completely dissolved leaving behind the organic lamella (*L*).

Magnification × 45.

D—Dentine.

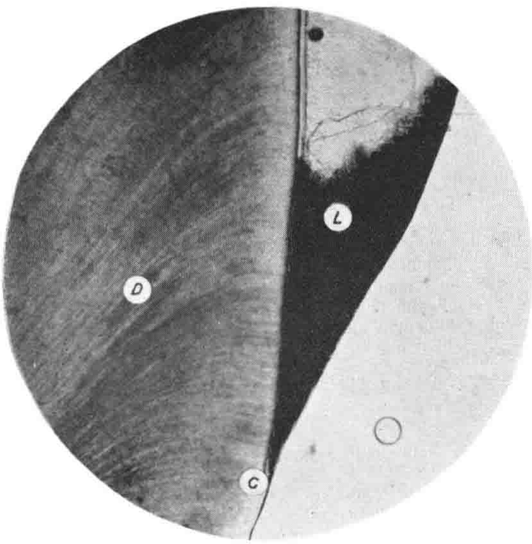


PLATE 11

DISTRIBUTION OF AN ENAMEL LAMELLA IN LONGITUDINAL PLANE

Longitudinal ground section of an unerupted tooth stained with silver nitrate and decalcified on the stage of the microscope. Magnification × 20.

The enamel was completely dissolved and a lamella (*L*) stained black by the silver nitrate remained as a thin leaf-like organic structure, extending from the cemento-enamel junction (*C*) for some distance towards the occlusal surface. *D*—Dentine.

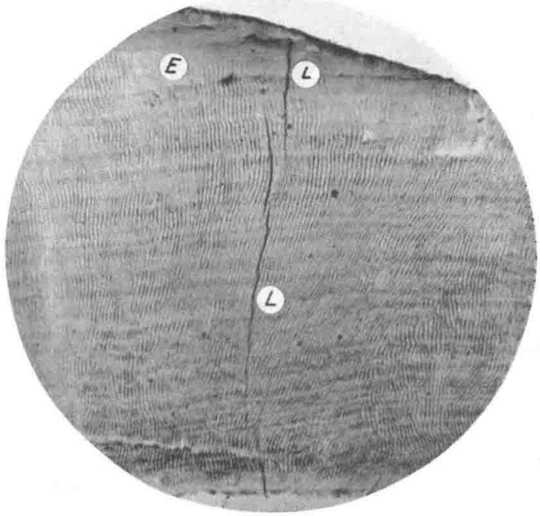


PLATE 12

ENAMEL LAMELLA

A lamella as seen in a transverse decalcified section of a fully formed but unerupted premolar tooth.

Magnification × 70.

L—Lamella. *E*—Enamel.

Stained by Mallory's method.

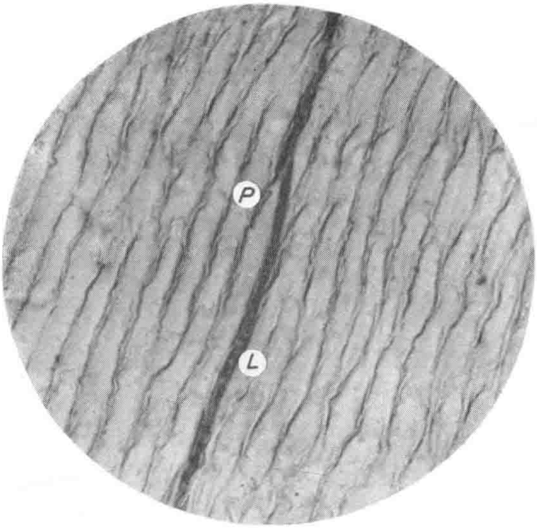


PLATE 13

ENAMEL LAMELLA

High magnification of part of the lamella illustrated in Plate 12 to show its relationship to the Prism Sheaths. Magnification × 785. *L*—Lamella. *P*—Prism Sheaths. Decalcified section. Stained by Mallory's method.

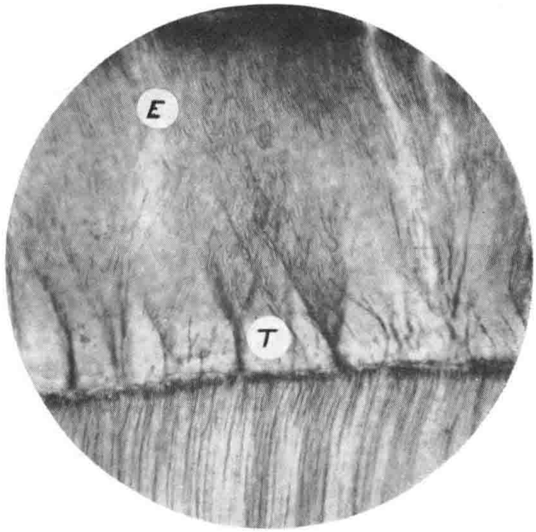


PLATE 14

ENAMEL TUFTS

Transverse ground section. Magnification × 75.

E—Enamel. *T*—Tufts extending into the Enamel from Amelo-dentinal junction.

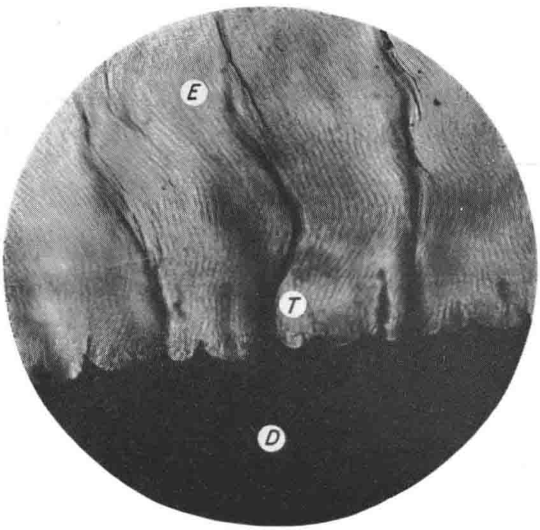


PLATE 15

ENAMEL TUFTS

Transverse ground section. Appearance of Enamel Tufts (*T*) focused in one plane under high magnification (× 390).

D—Dentine. *E*—Enamel.

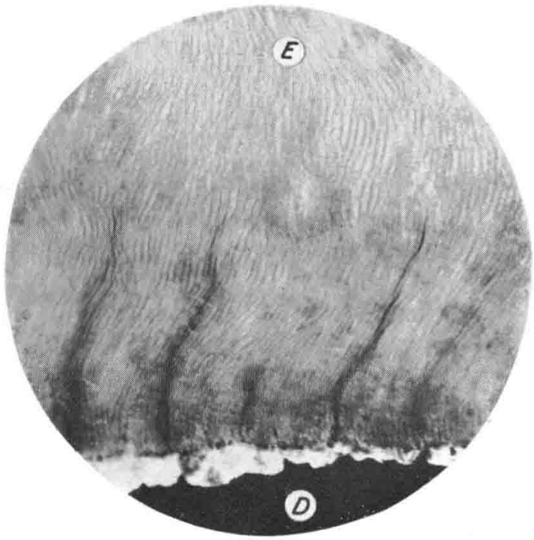


PLATE 16

ENAMEL TUFTS

Decalcified section of the mature enamel showing single hypocalcified fibres of the enamel tufts following the course of the enamel prisms.

Magnification × 220. *E*—Enamel. *D*—Dentine.

Stained by Mallory's method.