EXPERIMENTAL STUDIES IN CALCIFICATION

II. The Effect of a Rachitogenic Diet on the Alveolar Bone of the White Rat *

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The studies of bone growth in rickets thus far reported have been concerned chiefly with disturbances in growth of endochondral bone. Reports on the rachitic disturbances in endomembranous bone, uncomplicated by the presence of growing cartilage, are lacking except for frequent statements that the bone trabeculae are characteristically bordered by osteoid (Erdheim,[1] Becks and Ryder,[2] McLean [3]). Similarly, little attention has been given to a consideration of the resorption pattern in rachitic bone. The alveolar bone of the incisor and molar regions of the albino rat may serve as a good test object in the analysis of both apposition and resorption, since this bone is undergoing relatively rapid and continuous architectural reconstruction coincident with the physiologic movement of the teeth. In addition, the bone is always in a relatively constant relationship to the tooth which serves as a ready point of reference. An analysis of the alveolar bone, therefore, promises to be of special significance for the understanding of rachitic bone changes in general.

Material and Methods

The material and methods were the same as those used for the preceding paper (Table I).[4] Thirty-three white rats † were placed on a rachitogenic diet for a period of 1 to 56 days after weaning (at 21 days). In addition, a study was made of 25 litter-mates, 21 to 77 days of age, fed on a normal control diet. The Steenbock-Black [15] diet no. 2965, modified by the substitution of corn meal for whole yellow corn, was used.

The heads of the experimental and control rats were removed and fixed in 10 per cent formalin immediately after sacrifice. The jaws were dissected and portions bearing the upper incisors and molars were prepared for decalcified histologic sections. The incisors were cut in serial longitudinal sections and the molars in serial mesiodistal sections. The sections were stained with hematoxylin and eosin.

Microscopic Findings

A description of the findings in the experimental animals will be preceded by a brief presentation of the normal histologic structures.

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† The animals used in this series of studies were kindly made available by Drs. F. C. McLean and W. Bloom.

A. UPPER MOLAR REGION

Normal Animals

The alveolar bone (Text-Fig. 1-A and Fig. 1), as seen in mesiodistal section of the upper molar, consists of (1) a thin, compact basal plate which forms part of the boundary of the temporal fossa and part of the alveolar wall of the apices of the roots, and (2) the spongy interdental and interradicular septa. The periodontal borders of the septa tend to be continuous. The septum between the first and second molars assumes a triangular form. Its gingival half is dense and contains small marrow spaces that are filled with loose connective tissue. Its basal half contains larger intercommunicating spaces that are filled with red marrow.

The alveolar process in the bifurcation of the roots presents a spongy framework of thin bone trabeculae. It consists of a large central portion which is filled with red marrow, and a relatively narrow peripheral portion. The latter borders the periodontal membrane and contains loose connective tissue in its marrow spaces.

The osteoblasts are numerous at the crest of the interradicular and interdental septa. They are less prominent in the small bone-marrow spaces near the periodontal membrane. Osteoclastic resorption is seen frequently at the endosteal surfaces of the bone trabeculae.

Corresponding to the distal drift of the molars, bone apposition can be seen on the mesial alveolar walls, bone resorption on the distal walls. An exception is the alveolus of the mesial root of the first molar. The divergence of this root from the other roots of the first molar necessitates resorption at the mesial wall during the tipping occluso-distal movement of this tooth. The drifting movement of the rat molars continues throughout the life of the animal. It is, however, intermittent. During the rest periods thin layers of bone are apposed in small restricted areas upon the resorbed bone and the principal fibers of the periodontal membrane are reattached to the alveolar wall (Sicher and Weinmann [5]).

The bone trabeculae stain intensively with hematoxylin, suggesting normal calcification. Osteoid borders are almost entirely missing. Only an occasional extremely delicate eosin-staining seam is found at the crest of the interdental and the interradicular septa.

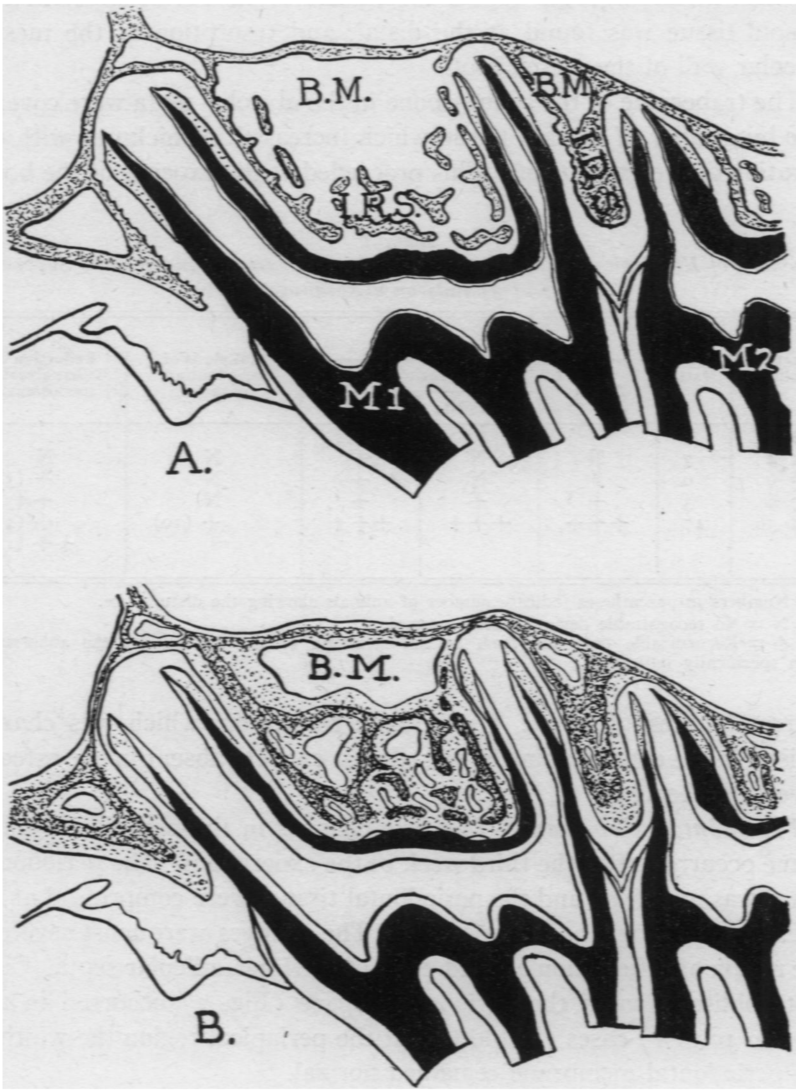
The *periodontal membrane* is of fairly uniform width.

Experimental Animals

Alveolar Bone. The alveolar bone presented a normal picture (Fig. 1) until the fifth day on the rachitogenic diet. At this time the alveolar crest showed an osteoid seam which (Table I) continued to increase in thickness throughout the duration of the experiment (Text-

Fig. 1 and Fig. 2). The maximal width of the osteoid tissue was not greater than the expected apposition of bone in a given area (Hoffman and Schour [6]).

As a result of the distal movement of the molars (Sicher and Wein-



Text-Fig. 1. *A*. Semidiagrammatic tracing of the first (M1) and mesial half of the second (M2) upper molar of a normal rat. The interradicular septum (I.R.S.) consists of thin, well calcified trabeculae enclosing a large marrow cavity (B.M.). The interdental septum (I.D.S.) is formed by a thick lamina at the crest, and trabeculae at the base enveloping a large marrow space (B.M.). The periodontal membrane, which is located between the alveolar bone and the roots, is of fairly even width. *B*. Semidiagrammatic tracing of same region as shown in *A*, but taken from a rachitic rat. The trabeculae are increased in thickness and the marrow spaces (B.M.) are decreased in size by apposition of osteoid tissue (lighter stippled areas). The periodontal membrane is reduced in width and for the most part obliterated at the crest of the interradicular septum.

mann [5]) the mesial alveolar wall showed apposition of osteoid tissue which gradually increased in thickness. The distal alveolar walls, on the other hand, showed chiefly progressive resorption, apposition of osteoid tissue occurring only in a few restricted areas. In the area of the first molar, because of the divergence of its roots, apposition of osteoid tissue was found at the distal, and resorption at the mesial, alveolar wall of the mesial root.

The trabeculae of the spongy bone in the alveolar septa were covered also by a layer of osteoid tissue which increased in thickness with the duration of the experiment. This proceeded at the expense of the bone-

TABLE I
Summary of Histologic Findings in the Upper Molars, Incisors, and Related Supporting Tissues of 33 Rats on a Rachitogenic Diet

Length of experiment	No. of rats	Osteoid alveolar bone			Ankylosis of periodontium of molar	Reduction of labial alveolar periosteum
		Molar	Incisor			
			Ling. plate	Lab. plate		
(*days*)						
1–4	7	N	N	+	N	N
5–6	6	?	N	+	N	+ (3)
7–8	3	+	+	+	N	+ (3)
21–56	17	+++	+++	+++	+ (10)	+ (4)
						++ (11)

Numbers in parentheses indicate number of animals showing the disturbance.
N = No recognizable deviation from normal.
+ = Recognizable deviation from normal structure or the presence of the abnormality when specifically indicated.

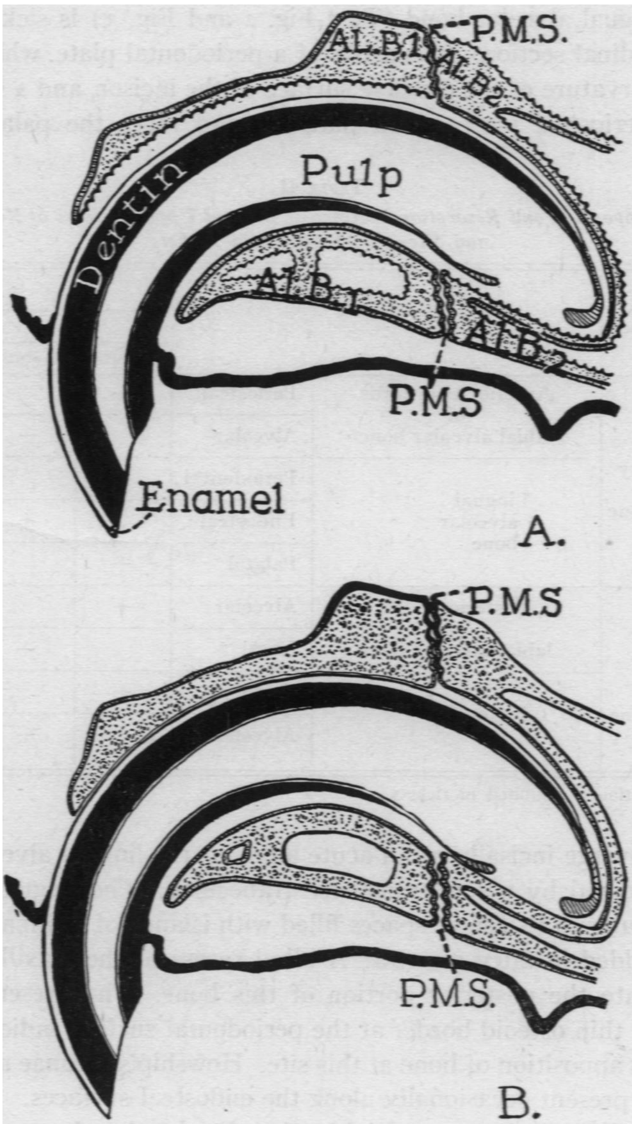
marrow spaces (Fig. 2). Osteoclastic resorption, which was characteristic in the control animals, was almost entirely absent in the osteoid-covered trabeculae.

Periodontal Membrane. The first changes in the periodontal membrane occurred after the third week of the experiment. The periodontal space was narrowed and the periodontal tissues were compressed at the sites of physiologic bone apposition. The changes were most severe in the region of bifurcation at the height of the interradicular septa. Complete obliteration of the periodontal space (Fig. 2) occurred in this area in 10 of 17 cases (Table I). At the periapical region the width of the periodontal membrane remained normal.

B. UPPER INCISOR REGION

Normal Animals

The alveolar bone of the upper incisor is divided into an anterior premaxillary and a posterior maxillary portion by the premaxilla-maxillary suture (Text-Fig. 2-A). The suture runs in an almost vertical plane. The anterior portion constitutes the anterior two-thirds of the labial bone and almost the entire lingual alveolar bone. The posterior portion



Text-Fig. 2. *A*. Semidiagrammatic tracing of the upper incisor of a normal rat. The alveolar bone consists of the anterior (Al.B. 1) and posterior portions (Al.B. 2) which are separated by the premaxilla-maxillary suture (P.M.S.). Scalloped borders indicate sites of resorption; double bars with crossbars indicate sites of apposition (see Table II). *B*. Semidiagrammatic tracing of the upper incisor of a rachitic rat, showing absence of sites of resorption. The width of the periodontal membrane is reduced or the membrane partially absent in regions where resorption normally occurs (see Table II).

constitutes the fundus and the posterior third of the labial alveolar bone. The labial alveolar bone consists of a thin premaxillary plate and a maxillary portion which serves as a thimble in which the basal end of the incisor rests.

The lingual alveolar bone (Text-Fig. 2 and Fig. 3) is sickle-shaped in longitudinal section. It consists of a periodontal plate, which parallels the curvature of the concave surface of the incisor, and a somewhat thicker periosteal plate which parallels and faces the palate. Both

TABLE II

Sites of Apposition and Resorption in Alveolar Bone of Upper Incisors of Normal Rat and Sites of Apposition in Rickets

Divisions of alveolar bone	Subdivisions		Normal		Rickets*
			Sites of		Sites of
			Apposition	Resorption	Apposition
Anterior or premaxillary portion of alveolar bone	Anterior two-thirds of labial alveolar bone	Periosteal	+		+
		Alveolar		+	−
	Lingual alveolar bone	Periodontal	+		+
		Endosteal		+	−
		Palatal	+		+
Posterior or maxillary portion of alveolar bone	Posterior third of labial alveolar bone	Alveolar	+		+
		Nasal		+	−
	Fundus	Nasal	+		+
		Alveolar		+	−

* Resorption is inhibited in rickets.

plates converge incisally at an acute angle at the lingual alveolar crest and are joined by a few transverse trabeculae. The lingual alveolar bone contains in its center spaces filled with islands of red marrow that are embedded in fatty marrow. A blind recess of the maxillary sinus extends into the posterior portion of this bone. The presence of an extremely thin osteoid border at the periodontal surface indicates relatively fast apposition of bone at this site. Howship's lacunae and osteoclasts are present occasionally along the endosteal surfaces.

The fundic bone is extremely thin. It is bordered on its nasal surface by a layer of mucous glands of the maxillary sinus (Fig. 10).

Table II gives the normal sites of apposition and of resorption in the alveolar bone of the upper incisor region.

Periodontal Membrane. The periodontal membrane, as a specialized connective tissue, may be classified into three portions:

1. The Periodontal Membrane Proper. The periodontal membrane

proper is confined to the concave and lateral cementum-covered surfaces of the incisor and serves as a suspensory ligament. In adaptation to the continuous eruption of the tooth, this ligament is arranged in three distinct layers (Fig. 5): the alveolar fibers, the dental fibers, and the intermediate plexus. The alveolar and dental fibers are arranged in a radial direction, *i.e.*, at right angles to the surface of the tooth. The alveolar fibers form strong bundles between which vessels and nerves are contained in loose connective tissue. The vessels are near the bone surface and run at right angles to the long axis of the tooth. The dental fibers form an almost continuous layer.

2. The Labial Alveolar Periosteum. The labial alveolar periosteum is confined to the convex side of the tooth (Fig. 7). It lies between the enamel organ and bone and consists of dense connective tissue, the fibers of which run parallel to the surface of the bone. The tissue is highly vascularized, with most of the vessels running close to the surface of the bone and parallel to the long axis of the tooth. Corresponding to the bones which form the alveolus at the convex side of the tooth, the labial alveolar periosteum consists of a premaxillary and maxillary portion.

3. The Fundic Portion. The fundic portion lies between an epithelial diaphragm and the fundic bone and is differentiated into the hammock ligament upon which the basal ends of the incisors rest and into a layer of very loose connective tissue which is adjacent to the tooth (Fig. 10).

Experimental Findings

Alveolar Bone. The reaction of the alveolar bone was different in the normal sites of bone apposition and in the normal sites of bone resorption.

In the normal sites of bone apposition the new formation of bone proceeded at a fairly normal rate but the calcification of the newly formed matrix was lacking. Here an increase in the width of osteoid tissue was observed beginning with the second week of the experiment (Text-Fig. 2 and Table II). Apposition of osteoid tissue (Table I) also occurred along the trabeculae of the spongy bone, especially in the lingual alveolar plate (Figs. 3 and 4). The gradual thickening of the trabeculae led to a narrowing of the marrow spaces.

In the normal sites of bone resorption (Text-Fig. 2) resorption proceeded until the calcified bone had been removed and the remaining bone consisted entirely of osteoid tissue when resorption no longer occurred. The bone now gradually increased in thickness because the continued apposition was not balanced by simultaneous resorption (Figs. 7 to 11).

Immediately anterior to the premaxilla-maxillary suture (Text-Fig.

2) the thin labial alveolar plate was connected with the frontal process of the premaxilla by a number of vertical bone trabeculae. These trabeculae were normally covered by osteoblasts. During the fifth week of the experiment they showed in many places wide seams of osteoid tissue, whereas their core consisted of well calcified bone (Fig. 12). When the resorption, proceeding at the periodontal surface of the premaxilla, reached this system of trabeculae, the different reaction of osteoid tissue and bone could be observed. Osteoclasts were seen attacking the calcified core of the trabeculae, whereas the osteoid tissue did not show signs of osteoclastic resorption (Fig. 13).

The Periodontal Membrane. The periodontal membrane proper, at the lingual or cementum-covered side of the tooth, remained, as a rule, normal in width. A narrowing of the space was observed only once. In advanced cases the arrangement of the suspensory fibers was markedly disturbed. The normal arrangement of the periodontal fibers (Fig. 5) in three layers was almost lost in the incisal portion where they followed a direct course from bone to the cementum (Fig. 6). A number of lymphoid wandering cells were found between the bundles of the principal fibers.

The labial alveolar periosteum of the tooth showed a marked difference in the premaxillary and maxillary portions of the alveolus. In the maxillary part no significant changes were seen. In the premaxillary part a gradual narrowing of the periodontal space (Table I) led to an increasing compression of the connective tissue and blood vessels (Figs. 8 and 9). In advanced stages the connective tissue underwent hyaline degeneration. The hyaline changes appeared in isolated areas as round or oval islands which later fused to form a trabeculae-like network (Figs. 8 and 9). The latter included connective tissue cells and sometimes multinucleated giant cells (osteoclasts). In its staining reaction the hyalin resembled osteoid tissue. Differentiation of the hyalin and the adjacent osteoid tissue was not always sharp. The absence of osteoblasts indicated that this tissue was not the result of apposition.

The fundic connective tissue underwent changes very similar to those of the premaxillary alveolar periosteum. The fundic space was gradually narrowed and the loose connective tissue and its blood vessels were compressed. In advanced stages the tissue adjacent to the bone underwent hyaline degeneration (Fig. 11).

Discussion

Growth of bone and its maintenance as a functioning organ is dependent upon the balanced interaction of bone apposition and bone resorption. The processes of apposition and resorption have to be studied with equal emphasis in order to understand fully the rachitic changes of the skeleton. The alveolar bone of the rat is a useful test object for such studies. The normal relations between bone and tooth and between the growth changes of the bone and the growth changes and physiologic movement of the teeth have been sufficiently well clarified to form a basis for experimental analysis (Sicher and Weinmann [5]). The pathologic changes in alveolar bone can be studied by examining the disturbances of the relation between bone and tooth. A rachitic diet acts primarily on the bone and dentin, but does not influence the shape of the teeth (Weinmann and Schour [4]).

Our findings agree with the generally accepted view that the primary cause of the pathologic changes following rachitogenic diet is the failure in calcification (McLean,[3] Pommer,[7] Howland,[8] Dodds and Cameron [9]). The mechanism by which some of the rachitic deformities are produced is secondary and depends on the peculiar anatomy and physiology of each region, and especially on the local pattern of apposition and resorption.

A. *The Spongy Bone*

In the spongy bone next to the bone marrow the trabeculae thicken and the marrow spaces become narrow as a result of the slackening and final cessation of resorption. The reason for the inhibition of resorption appears to be the failure of the newly formed bone to calcify. Osteoid tissue is almost immune to resorption, as are the uncalcified cementum (cementoid) and the uncalcified dentin (predentin) (Gottlieb,[10] Orbán and Weinmann,[11] Kronfeld [12]). The resistance of osteoid tissue to resorption seems to be caused not only by its lack of calcium salts but by the lack of those changes in the organic matrix which precede or accompany calcification. That the rachitic changes in spongy bone are a result of an inhibition of resorption and not of an overproduction of new bone is indicated by the fact that osteoclasts are absent in advanced stages and that measurements at sites of regular undisturbed bone formation, as at the crest of the alveolar septa of the molars, indicate a normal rate of bone apposition. McCollum, Simmonds, Shipley, and Park [13] observed a reduction in resorption in experimental rickets. They explained this lack of resorption on the basis of changes occurring in the osteoblasts and cartilage cells.

B. *The Alveolar Bone of the Molar Region*

In a majority of cases an encroachment of the periodontal membrane in the region of bifurcation occurred after 3 weeks on the experimental diet. A reduction in width of the periodontal membrane was found on the mesial side, whereas the periodontal membrane remained normal on the distal side and at the fundus. These findings may be explained on the basis of the normal growth pattern of the jaws. The occlusal movement of the molars is coordinated with, and made possible by, the increase of distance between maxillary and mandibular body as a consequence of the growth of the mandibular ramus. The latter increases in height by endochondral bone growth at the mandibular condyle. The condylar growth is in every respect the same as the longitudinal growth of the shaft of the long bone at the epiphyseal cartilage.

We know that the endochondral epiphyseal growth of bone is considerably retarded in experimental rickets (Dodds and Cameron [9]), and probably the same holds true for the condylar growth of the mandible. Thus space for the eruption of the molars cannot be provided to the normal extent in rachitic rats and the occlusal movement of the molars is therefore mechanically checked.

In the normal rat the alveolar bone of the molar shows three distinct zones of apposition (Hoffman and Schour [6]). The greatest amount of apposition occurs at the crest of the alveolar septa, less at the mesial alveolar, and least at the fundus. It has been suggested (Sicher and Weinmann [5]) that the apposition at the crest of the interradicular septa causes the vertical eruption of the molar, that the apposition of bone at the fundus is secondary to the occlusal eruption, and that the distal drift of the rat molar is caused by apposition of bone at the mesial alveolar wall. As the apposition of bone at the crest of the interradicular septum of rachitic animals proceeds, the periodontal spaces at the bifurcation of the immobilized molar is gradually narrowed and finally obliterated. Ankylosis between bone and molars in rachitic rats was reported previously (Becks and Ryder,[2] Orbán and Weinmann [11]). The progressive apposition of bone at the mesial alveolar wall narrows the mesial periodontal space of the immobilized tooth. The bone formation at the fundus of the molar is greatly inhibited, apparently because the tooth is not elevated in its socket.

C. The Alveolar Bone of the Upper Incisor Region

A marked reduction of the periodontal membrane has been observed along that part of the alveolus where resorption normally occurs, that is, the premaxillary labial portion and the maxillary fundic portion (Figs. 9 and 11). Since the reason for this physiologic resorption is different in these two areas, the mechanism of the pathologic changes will be considered separately.

The Premaxillary Labial Portion. In the premaxilla the alveolus of the normal rat is widened by resorption at the convex side of the tooth, mainly because of the increase of the diameter of the incisor (Sicher and Weinmann [5]).

The widening of the alveolus in the premaxilla comes to a standstill in rachitic rats when the calcified bone present at the beginning of the experiment has been resorbed. Then the premaxillary alveolar plate at the convex side of the tooth consists only of osteoid tissue, which is resistant to resorption. Since the growth of the incisor in diameter progresses normally (Weinmann and Schour [4]), the tooth encroaches upon the periodontal tissues on the convex side (Figs. 8 and 9). Thus the width of the periodontal space is narrowed and later on the periodontal tissues are compressed between the growing tooth and the unyielding osteoid tissue. The impairment of the circulation of the blood in this area leads to hyaline degeneration of the connective tissue. The premaxillary periodontal space on the convex side of the incisor is finally obliterated.

The Maxillary Fundic Portion. Sutural growth between maxilla and premaxilla complicates the relation between the maxillary part of the alveolus and the teeth. If the tooth is considered as the fixed point, growth in the premaxilla-maxillary suture moves the fundic plate toward the basal end of the tooth and the maxillary alveolar plate at the convex side of the tooth away from the tooth. A reduction of the periodontal width at the fundus and an increase in the periodontal width at the convex side of the tooth would result if these tendencies were not compensated by resorption at the fundus and apposition at the maxillary alveolus on the convex side of the tooth (Text-Fig. 2). This picture of the normal animal has to be taken as a basis for the understanding of rachitic changes. In advanced rickets, the resorption of osteoid tissue fails and therefore the resorption of the fundic bone ceases. Since, however, growth in the suture continues, the periodontal width continues to be reduced (Fig. 11) and the periapical tissue may even become compressed and may undergo hyaline degeneration. The widening of the maxillary periodontal space at the convex side of the incisor by sutural growth and the apposition of osteoid tissue in those areas continue. The maxillary part of the periodontal membrane at the convex side of the tooth shows, therefore, no pathologic changes in rachitic rats.

Eruption

The eruption of the teeth in experimental rickets is retarded. Although no actual measurements of the rate of eruption have been made in rachitic animals, the histologic observations are convincing. The encroachment of the periodontal membrane between interradicular septa and the molars indicates clearly an arrest of the vertical movement of these teeth. The retardation of the eruption of the rat incisor is indicated by the formation of a thick layer of cementoid tissue and by the disorganization of the periodontal membrane (Fig. 6). The division of periodontal membrane into three layers, which is an adaptation to rapid longitudinal eruption (Sicher [14]), disappears almost entirely. As discussed previously, the disturbance of eruption appears to be secondary to the retardation of bone growth at the mandibular condyle.

Summary and Conclusions

This histologic study is based on 33 rats which were placed on a rachitogenic diet for a period of 1 to 56 days beginning with weaning. The histologic findings were:

1. The formation of new bone seems to proceed at a normal rate but it remains uncalcified and persists as osteoid tissue.

2. Osteoid tissue fails to undergo resorption.

3. The consequences of the failure of resorption of osteoid tissue are:

a. Excessive accumulation of osteoid tissue. The sites which normally show apposition continue to do so while the sites which normally show resorption are inactive.

b. Distortion of the growth pattern of the alveolar bone, since the normal growth pattern depends upon a balance between apposition and resorption.

c. Reduction of the periodontal space in definite areas. Compression of the periodontal tissue and its blood vessels leads to hyaline degeneration of the connective tissue and in some instances to a complete obliteration of the periodontal membrane.

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[*Illustrations follow*]

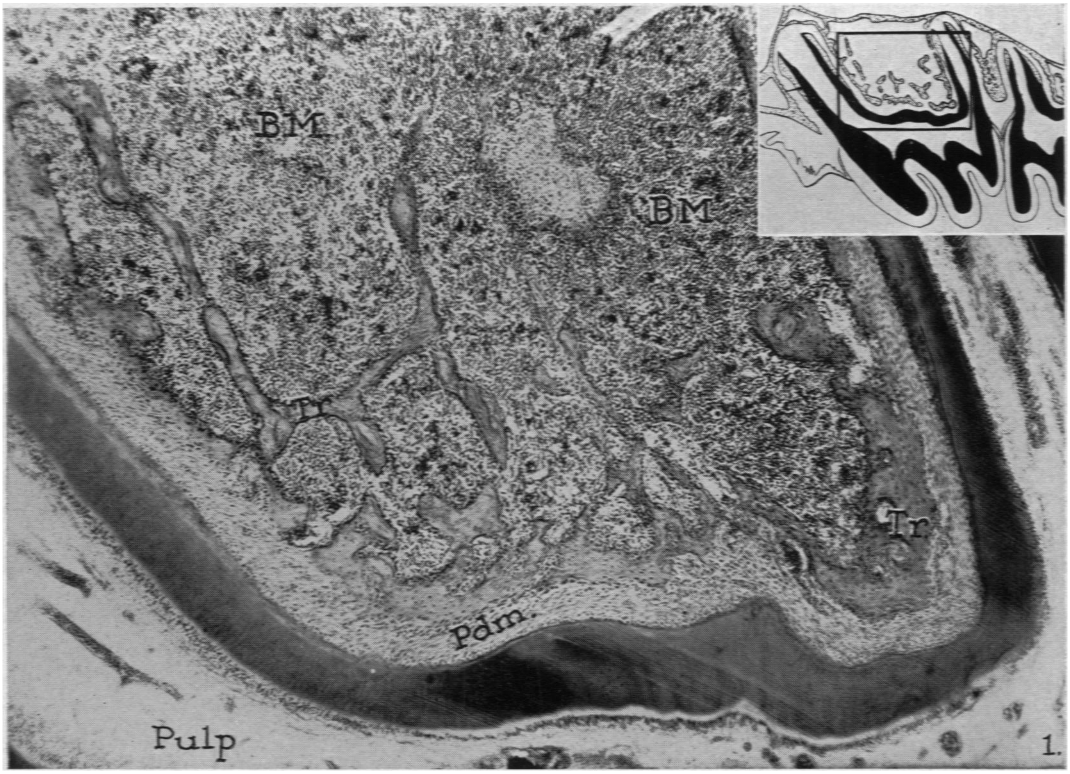
DESCRIPTION OF PLATES

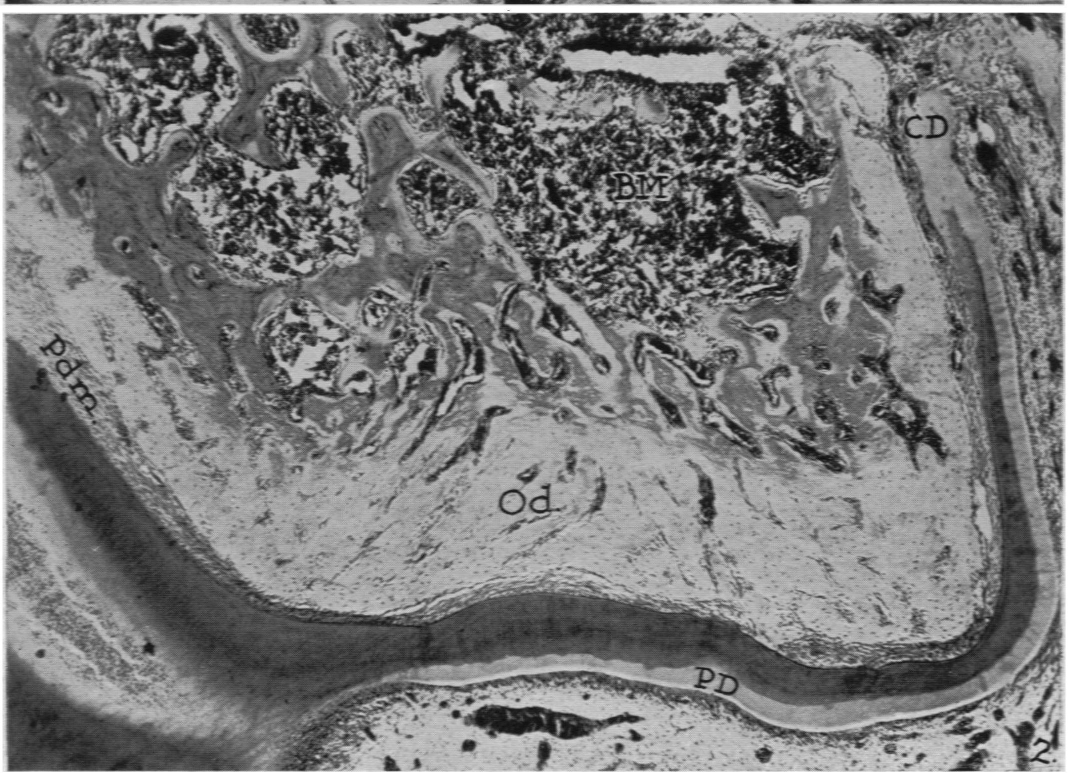
PLATE 137

Photomicrographs of a mesiodistal section of the interradicular septum of a first upper molar. This area is indicated in the insert in Figure 1. × 58.

FIG. 1. Normal control rat 2901, 49 days old. Section shows thin, calcified bone trabeculae, Tr., the large marrow spaces, BM, and the even width of the periodontal membrane (Pdm.).

FIG. 2. Rat 1202, 52 days old. This animal was weaned at 21 days and then placed on the rachitogenic diet for 31 days. Section shows increased thickness of predentin (PD), cementoid (CD), and osteoid (Od.), narrowing of the marrow spaces (BM), and almost complete reduction of the periodontal membrane (Pdm.).


BM
BM
Tr
Tr
Pdm.
Pulp
1.


CD
BM
pdm
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2.

Plate 138

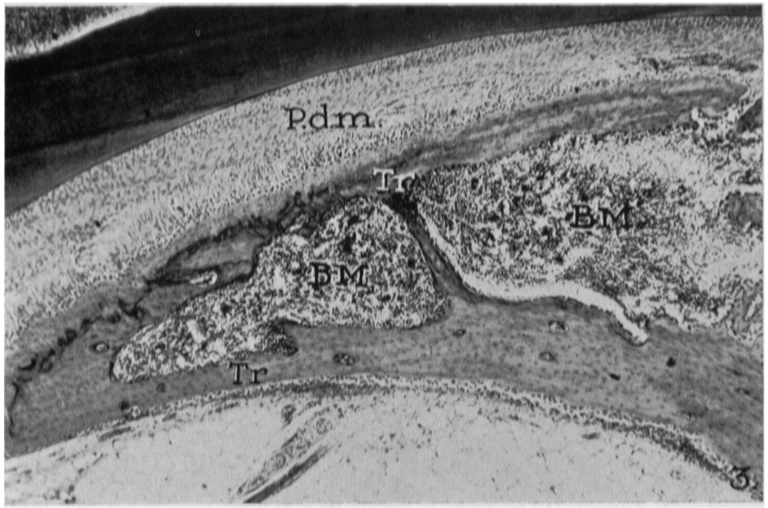
Photomicrographs of a midsagittal section of the lingual alveolar bone of the upper incisor. This area is indicated in the insert in Figure 5.

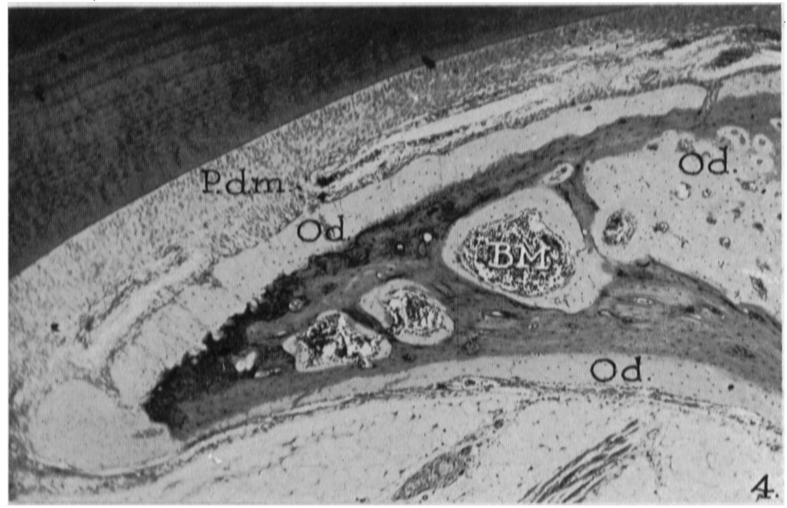
Fig. 3. Normal control rat 2901, 49 days old. The homogeneous calcification of the thin bone trabeculae (Tr) and large marrow spaces (BM) are to be noted. P.d.m. = periodontal membrane. × 52.

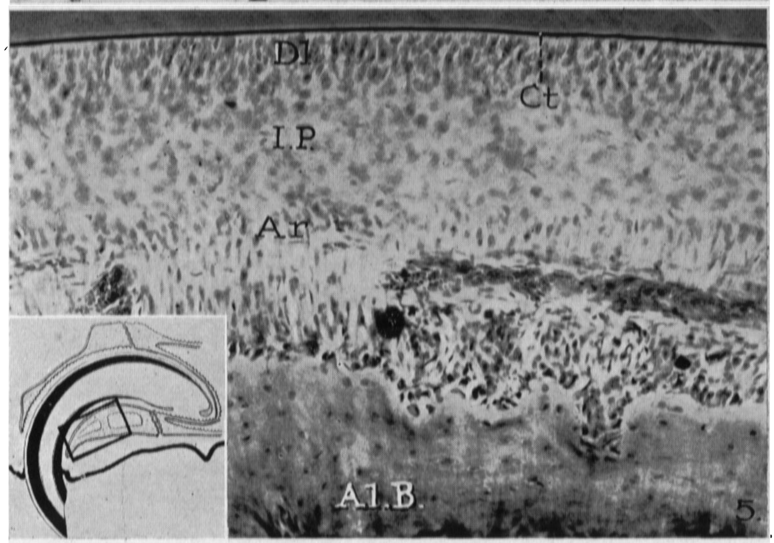
Fig. 4. Rat 1202, 52 days old, placed on the rachitogenic diet for 31 days after weaning. There is a thick layer of osteoid tissue (Od.) and the marrow spaces (BM) are reduced. × 52.

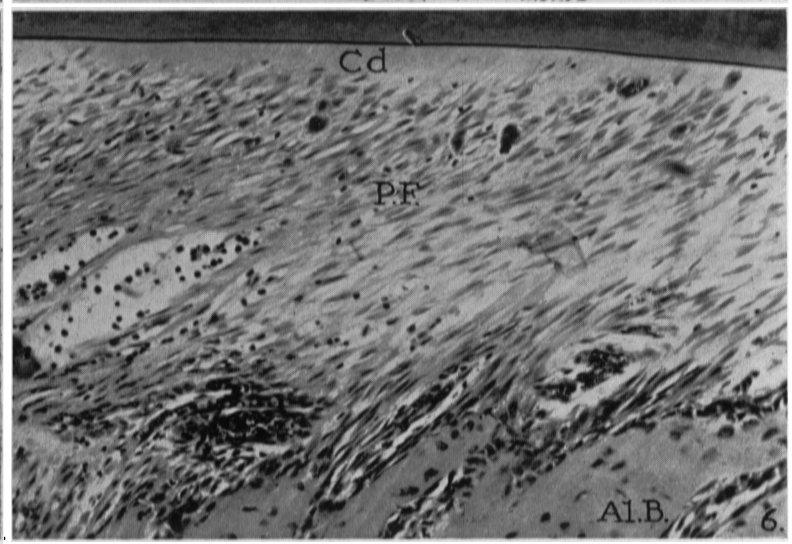
Fig. 5. Normal control rat 3601. Magnified area of periodontal membrane. Of note are the thin layer of cementum (Ct) and the division of the principal fibers into alveolar (Ar) and dental (Dl) fibers, and intermediate plexus (I.P.) Al.B. = alveolar bone. × 160.

Fig. 6. Rat 1802, 67 days old, placed on the rachitogenic diet for 46 days after weaning. Field corresponding to that of Figure 5, showing wide layer of cementoid tissue (Cd.) and the direct course of the principal fibers (P.F.) from alveolar bone (Al.B.) to cementum. × 160.









Weinmann and Schour

Effect of Rachitogenic Diet on Alveolar Bone

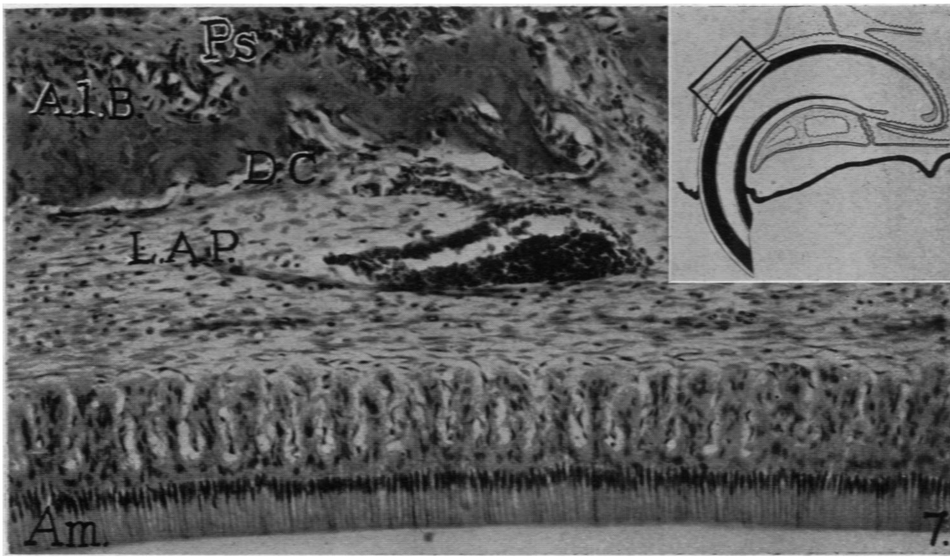
Plate 139

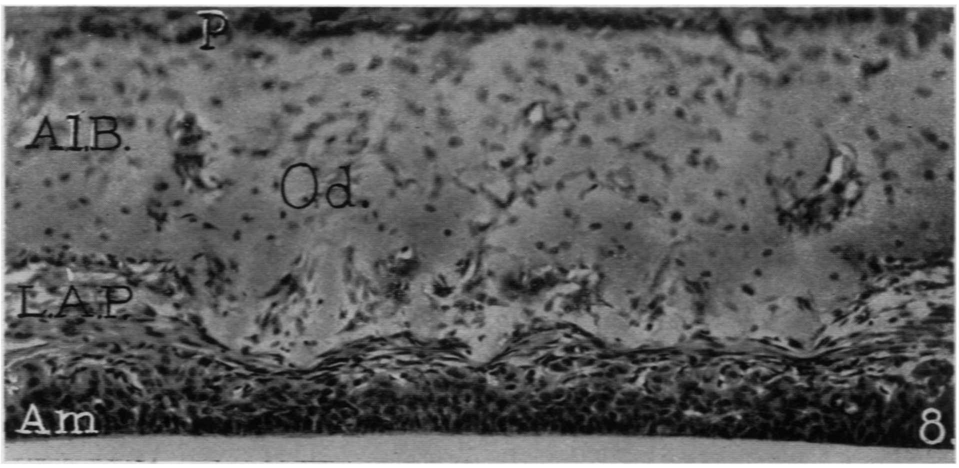
Photomicrographs of decalcified midsagittal section of the labial alveolar periosteum of mid-region of upper incisor. This area is indicated in the insert in Figure 7. Am. = ameloblasts; Al.B. = alveolar bone.

FIG. 7. Normal control rat 2901, 49 days old. There is apposition of bone at the periosteal (Ps) and resorption at the dental (D.C.) surface of the alveolar bone. The width of the alveolar bone and the labial alveolar periosteum (L.A.P.) may be compared with that of Figures 8 and 9. × 172.

FIG. 8. Rat 1802, 67 days old, placed on the rachitogenic diet for 46 days after weaning. To be noted are the presence of osteoblasts on the periosteal surface (P); the absence of resorption at the dental surface of the thickened alveolar bone, which now consists of osteoid tissue (Od.); and the compression and hyaline degeneration of the labial alveolar periosteum, L.A.P. × 172.

FIG. 9. Rat 2902, 49 days old, placed on the rachitogenic diet for 28 days after weaning. Of note here are the increased thickness of the alveolar bone (Al.B.), the replacement of the labial alveolar periosteum by osteoid (Od.) and hyaline connective tissue; and the compression of the enamel organ. × 172.


Ps
Al.B.
D.C
L.A.P.
Am.
7.


P
Al.B.
Od.
L.A.P.
Am
8.

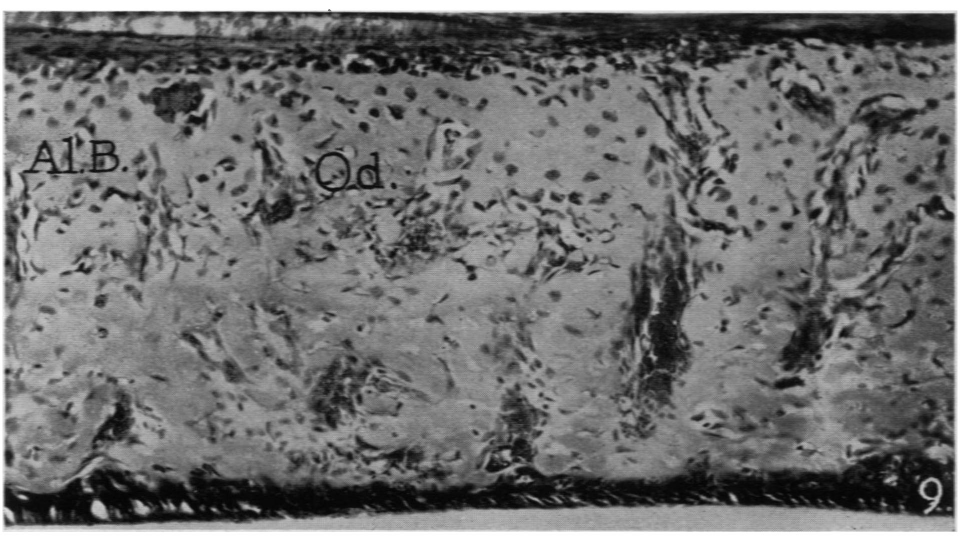
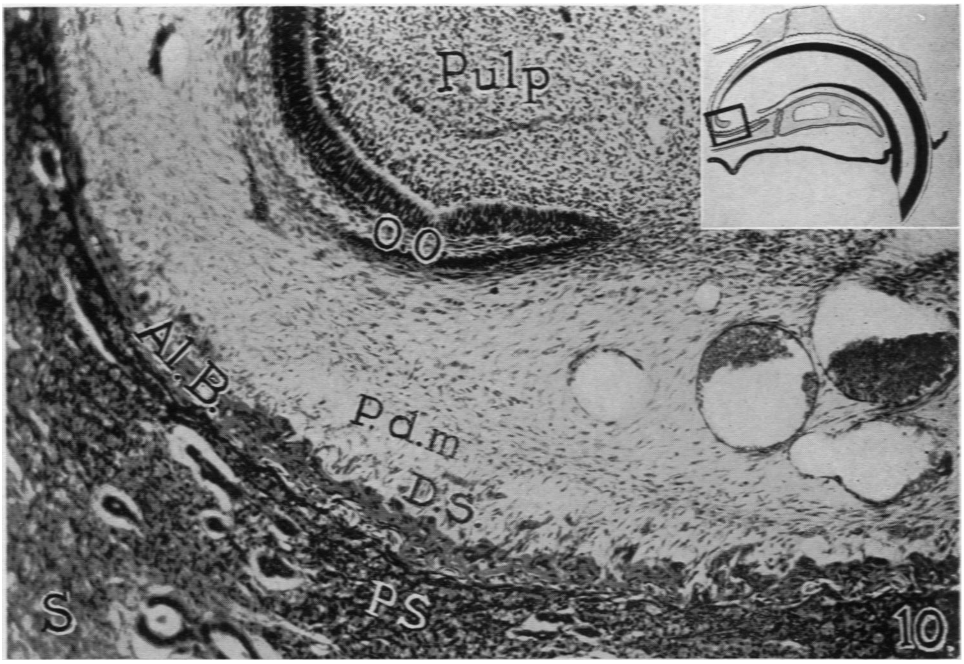

Al.B.
Od.
9.

Plate 140

Photomicrographs of decalcified midsagittal section of the labial fundic portion of the upper incisor. This area is indicated in the insert in Figure 10. Al.B. = fundic alveolar bone; O.O. = odontogenic organ; P.d.m. = periodontal membrane; S = mucous gland. ×120.

Fig. 10. Normal control rat 102, 53 days old. Apposition of bone at the periosteal surface (P.S.) and resorption at the dental surface (D.S.) of the alveolar plate.

Fig. 11. Rat 403, 53 days old, placed on the rachitogenic diet for 32 days after weaning. Reduction of the periodontal membrane (P.d.m.) in width; lack of calcification and increase of the bony plate (Al.B) in thickness; and partial replacement of the periodontal membrane by hyaline tissue are the significant features.


Pulp
O.O
Al.B.
P.d.m
D.S
S
PS
10

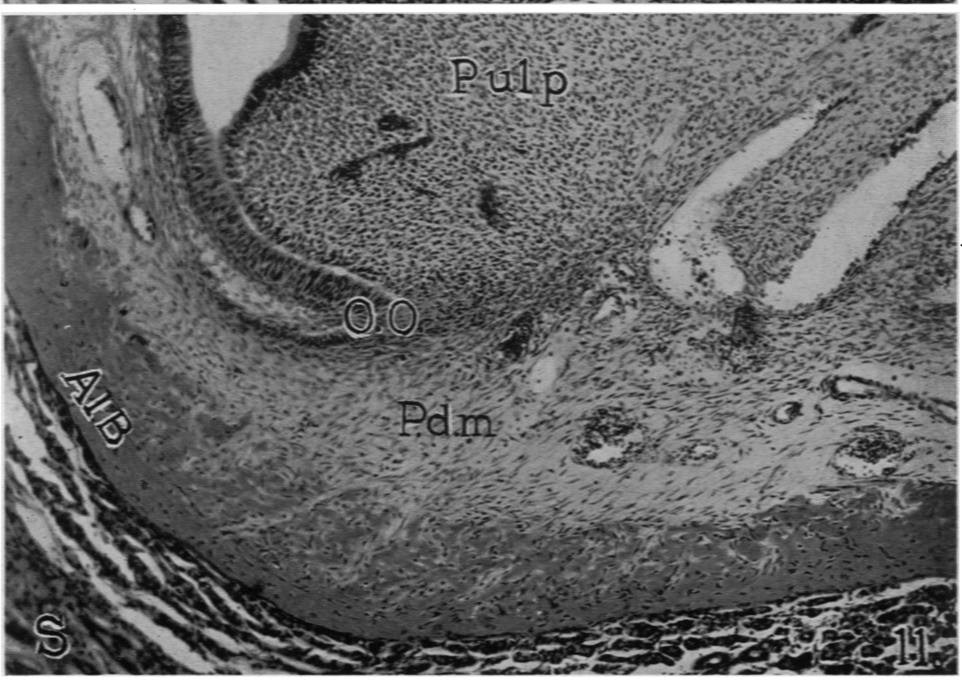
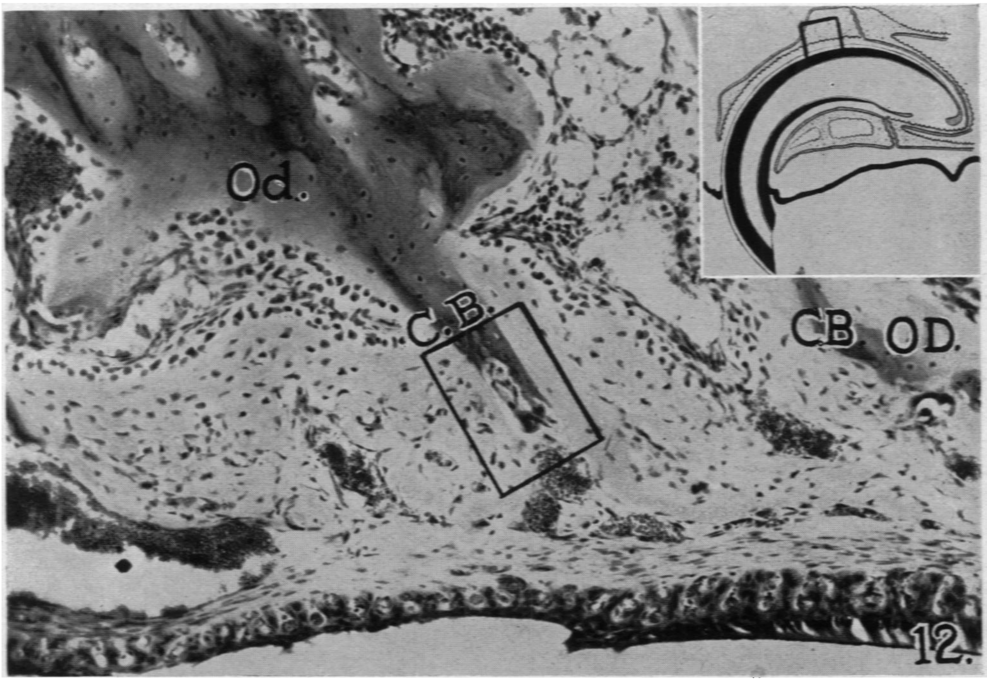
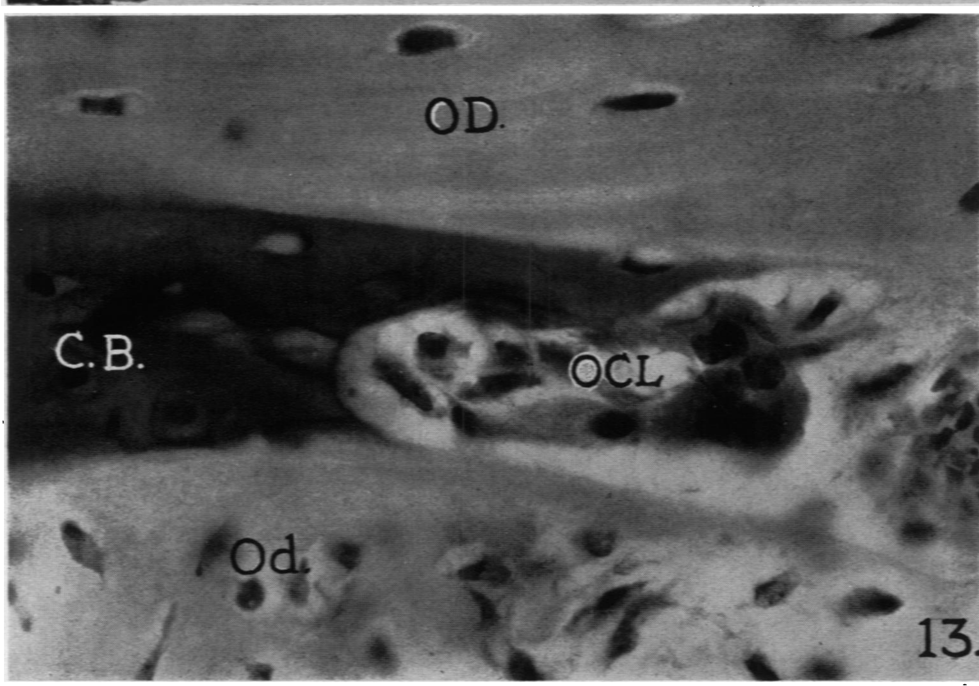

Pulp
O.O
Al.B
P.d.m
S
11

Plate 141

Fig. 12. Photomicrograph of midsagittal section of the labial alveolar bone of upper incisor of rat 2902, 49 days of age, which was weaned when 21 days old and fed the rachitogenic diet for 28 days. This area is indicated in the insert. Core of trabeculae consists of calcified bone (CB) and peripheral layers of osteoid tissue (Od.). × 150.

Fig. 13. Higher magnification of the area indicated in Figure 12, showing osteoclastic (OCL) resorption of the calcified core (CB) of the bone trabecula and resistance of the osteoid tissue (Od.) to resorption. × 800.


Od.
C.B.
CB
OD.
12.


OD.
C.B.
OCL
Od.
13.