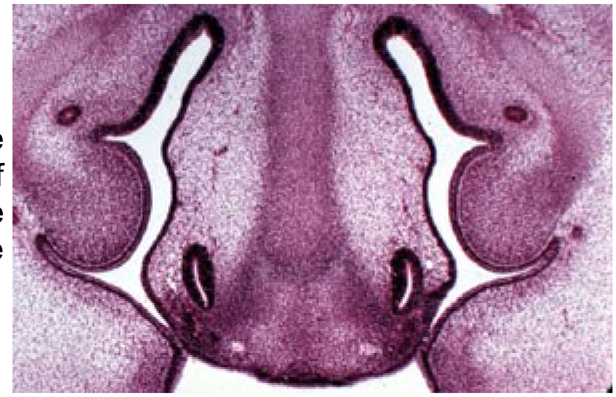
Embryology

Development of the Stomodeum

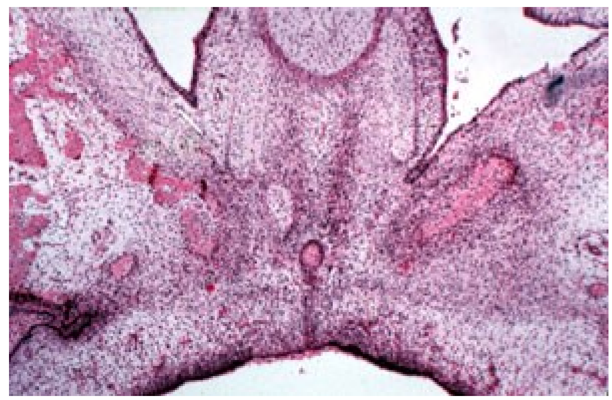
Image 1 Coronal section



The primitive nasal septum is located in the center of the field. Notice the concentration of cells in an area of chondrogenesis. The developing nasal conchae bulge toward the nasal septum bilaterally. H & E, 40x

Development of the Stomodeum

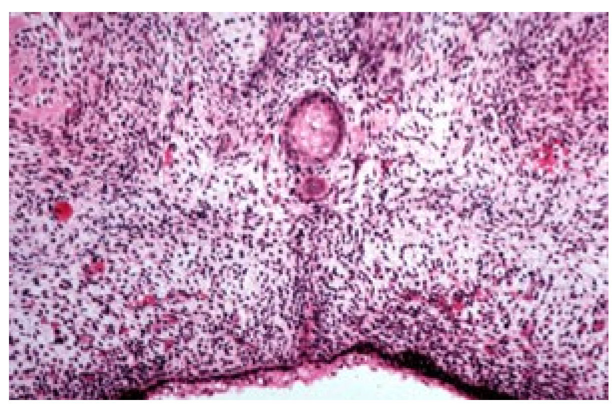
Image 2 Coronal section



The horizontal lateral palatine processes are fusing with each other and with the nasal septum. Notice the epithelial line of fusion within the palate. H & E, 40x

Development of the Stomodeum

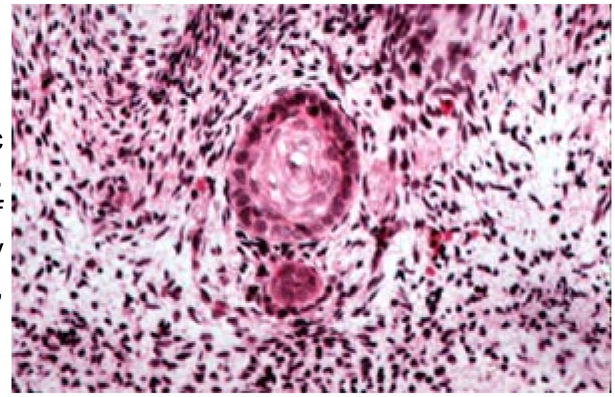
Image 3 Coronal section



Higher power of image 2. H & E, 100x

Development of the Stomodeum

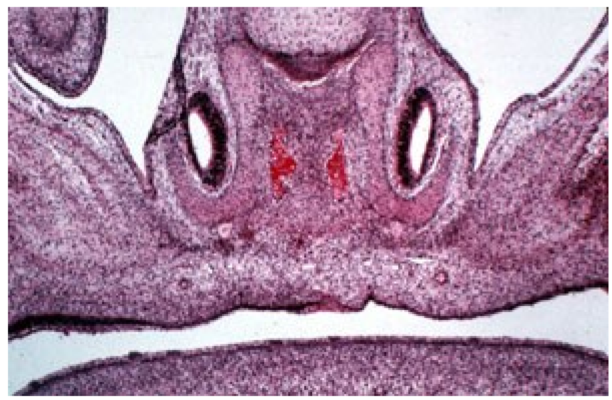
Image 4 Coronal section



The large and small structures with concentric epithelial cells are termed epithelial pearls. Epithelium which persists along the line of fusion of the lateral palatine processes may give rise to a fissural cyst later in life. H & E, 200x

Development of the Stomodeum

Image 5 Coronal section



The palate separates the nasal cavity from the oral cavity. Observe the fetal hyaline cartilage and the areas of intramembranous bone formation within the nasal septum which divides the nasal cavity into left and right chambers. The dorsal surface of the tongue is located at the bottom of the photomicrograph. H & E, 40x

Development of the Stomodeum

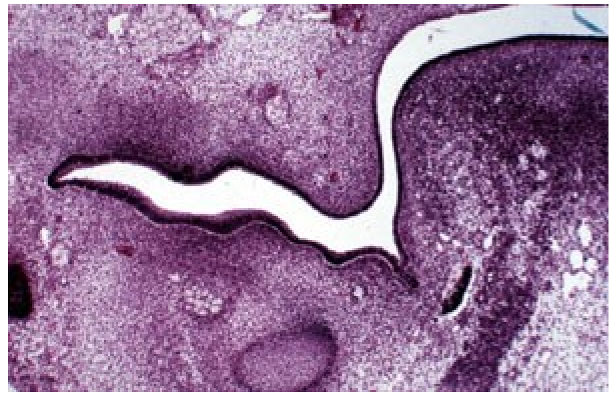
Image 6 Coronal section

A bar of fetal hyaline cartilage supports each of the three structures. H & E, 40x

Development of the Stomodeum

Image 7 Coronal section

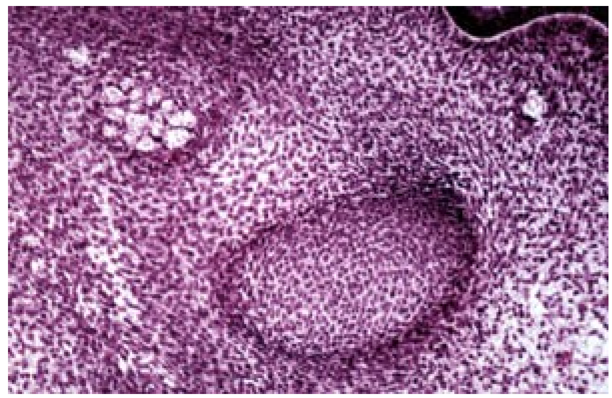
The tongue is located at the right side of the photomicrograph. Identify the lateral palatine process, Meckel's cartilage and the nerves developing within the mandible and the maxilla. H & E, 40x



Development of the Stomodeum

Image 8 Coronal section

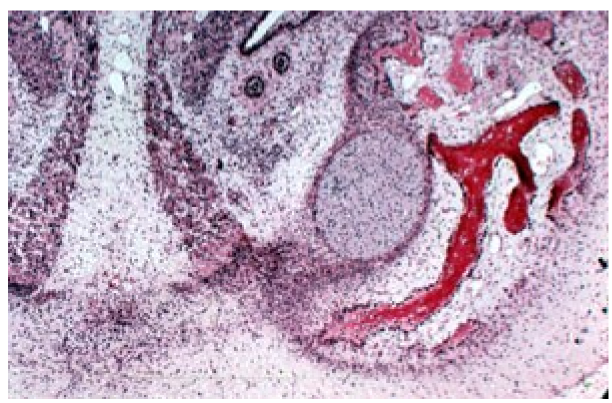
Higher power of image 7. Meckel's cartilage and the developing mandibular nerve are in view. H & E, 100x



Development of the Mandible

Image 9 Coronal Section

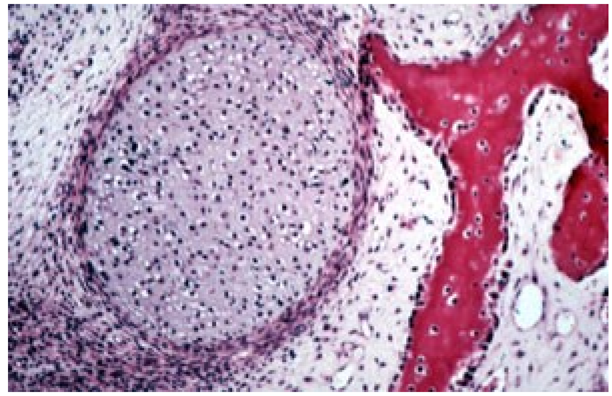
Meckel's cartilage and intramembranous osteogenesis (neural bone) are illustrated. Bundles of extrinsic tongue muscles are also present. H & E, 40x



Development of the Mandible

Image 10 Coronal Section

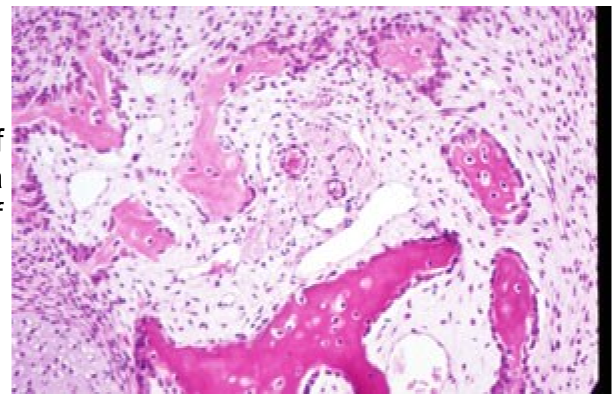
Higher power of image 9. Meckel's cartilage appears with an enveloping perichondrium and a spicule of woven bone. H & E, 100x



Development of the Mandible

Image 11 Coronal Section

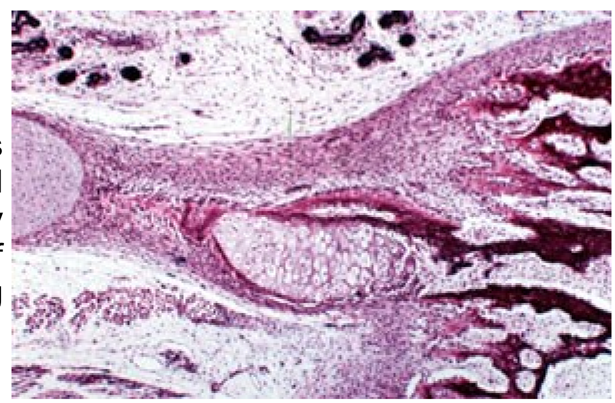
Higher power of of image 9. The process of intramembranous bone formation around a neurovascular bundle gives rise to an area of neural bone. H & E, 100x



Development of the Mandible

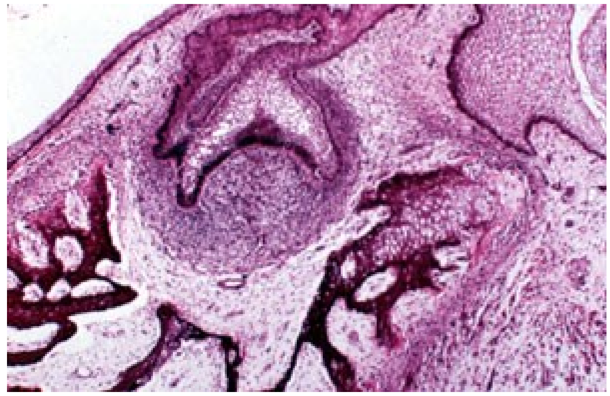
Image 12 Sagittal Section

Observe the areas of intramembranous osteogenesis and segments of "normal" and "hypertrophied" Meckel's cartilage. The deeply stained basophilic cells located at the top of the field are epithelial cords of the developing salivary glands. H & E, 40x



Development of the Mandible

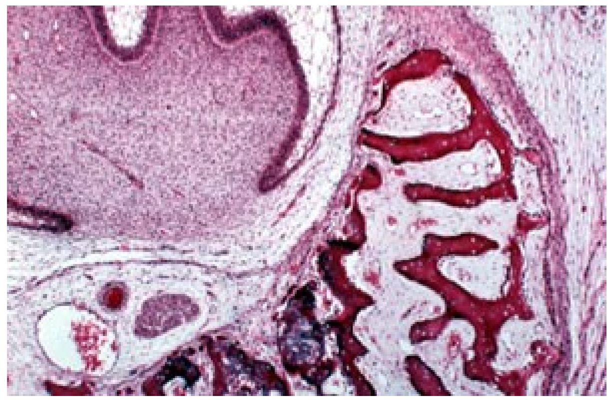
Image 13 Sagittal Section



A developing tooth germ (bell stage) is located in the center of the photo-micrograph. Primary spongiosa is forming a bony crypt in which the tooth germ develops. Notice the site of endochondral ossification in Meckel's cartilage. The floor of the oral cavity is located at the top left corner of the photomicrograph. H & E, 40x

Development of the Mandible

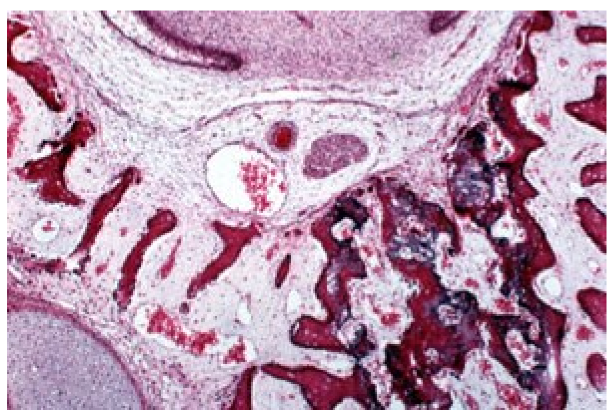
Image 14 Coronal Section



A bell stage of tooth formation is supported by a bony crypt. The supporting side walls of the crypt are termed the alveolar plates. A section of the mandibular neurovascular bundle is located inferior to the tooth germ. H & E, 40x

Development of the Mandible

Image 15 Coronal Section

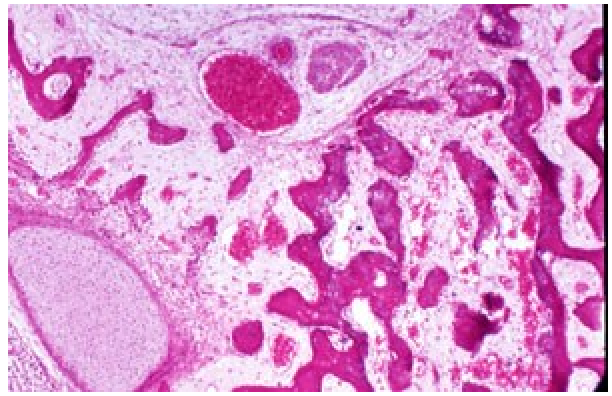


Observe the trough-like structure of the primary spongiosa which partially envelops the tooth germ, the mandibular nerve and blood vessels. A segment of Meckel's cartilage is at the bottom left of the field. H & E, 40x

Development of the Mandible

Image 16 Coronal Section

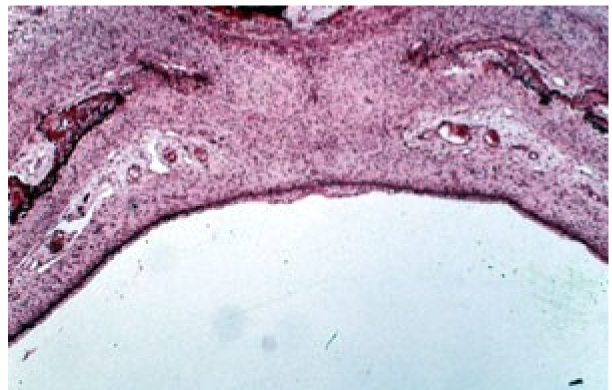
Histologic section similar to image 15 .H & E, 40x



Development of the Palate

Image 17 Coronal Section

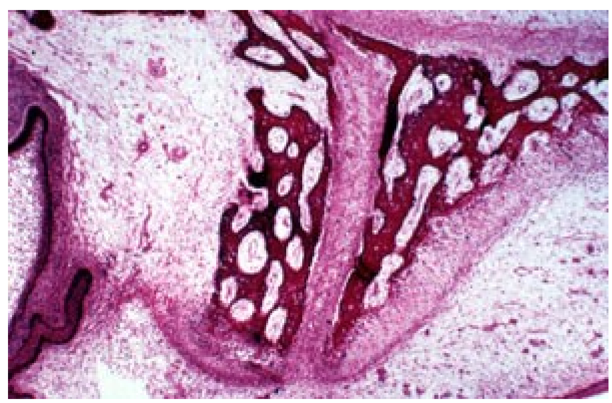
Note the ossification of the palate. The clear area on the slide is the oral cavity. H & E, 40x



Development of the Palate

Image 18 Sagittal Section

Notice the incisive canal which marks the boundary between the premaxilla and the maxilla proper. The canal contains the nasopalatine nerve and blood vessels. A section of a maxillary incisor tooth germ is visible at the left border of the photomicrograph. H & E, 40x



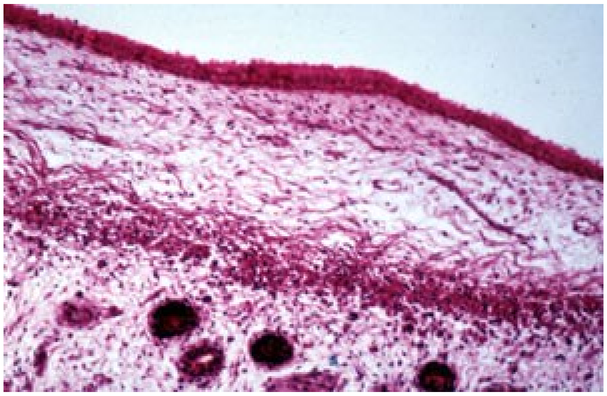
Development of the Palate

Image 19 Sagittal Section

Note the junctional area between the developing hard and soft palates. Immature pseudostratified columnar epithelium and stratified squamous epithelium line the nasal and oral surfaces of the palate, respectively. The dorsum of the tongue is visible at the bottom of the field. H & E, 40x

Development of the Palate

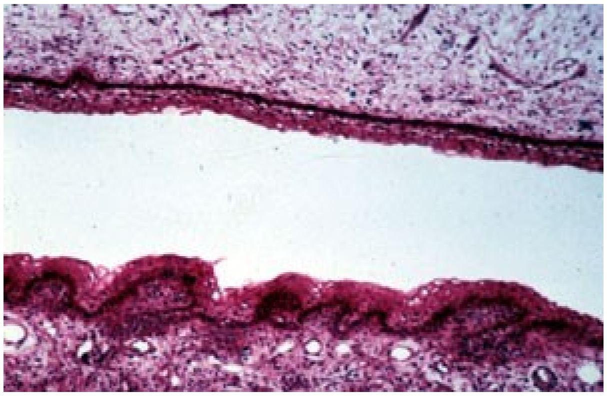
Image 20 Sagittal Section



Higher power of image 19. The epithelial cords of the developing salivary glands and striated skeletal myogenesis are evident. The nasal cavity is located at the top of the photomicrograph. H & E, 100x

Development of the Palate

Image 21 Sagittal Section

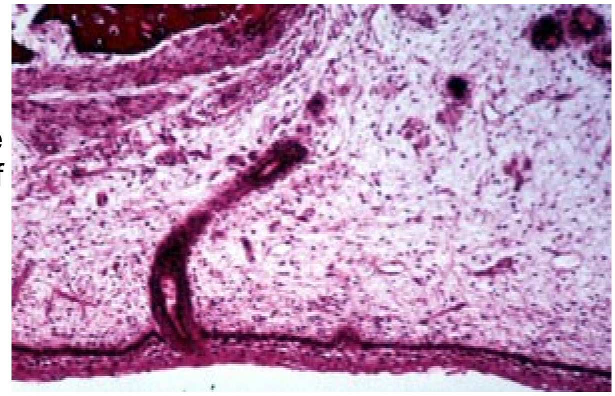


Higher power of image 19. The developing palate and tongue are located at the top and bottom of the photomicrograph, respectively. H & E, 100x

Development of the Palate

Image 22 Sagittal Section

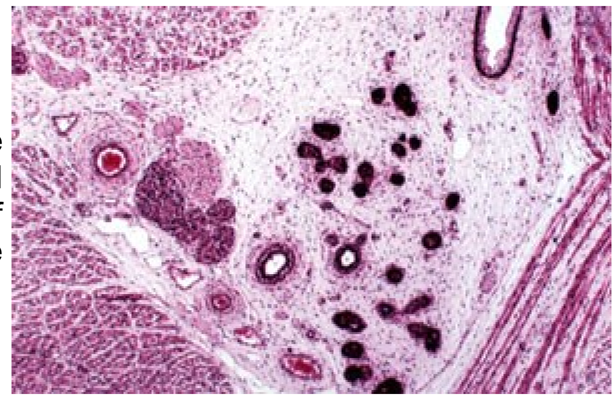
Higher power of image 19. Notice the proliferation of the oral epithelium at the site of salivary gland origin. H & E, 100x



Salivary Gland Development

Image 23

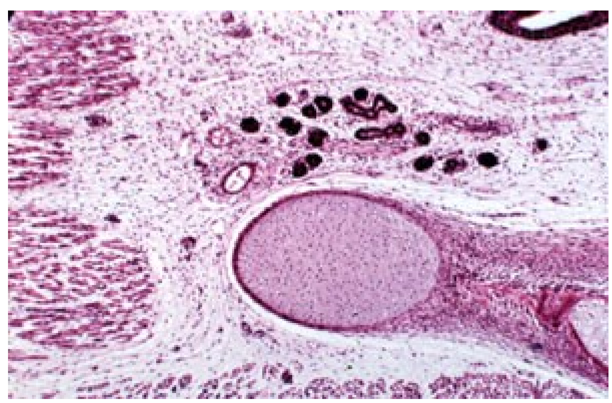
Major salivary glands developing in the mandible. Observe the basophilic epithelial cords some of which are canalized. Bundles of striated skeletal muscle and blood vessels are also present. H & E, 40x



Salivary Gland Development

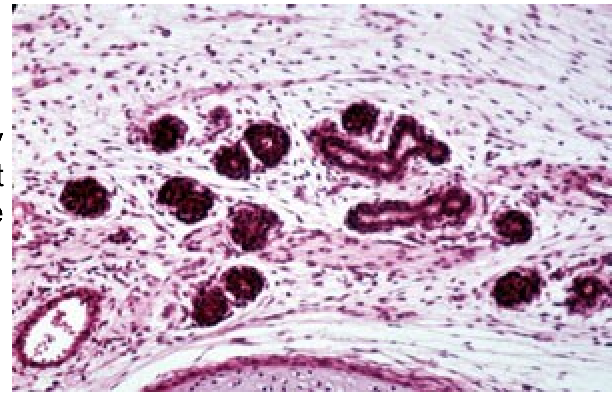
Image 24

Anlage of a salivary gland. Epithelial cords which will develop into a future salivary gland and Meckel's cartilage are evident. H & E, 40x



Salivary Gland Development

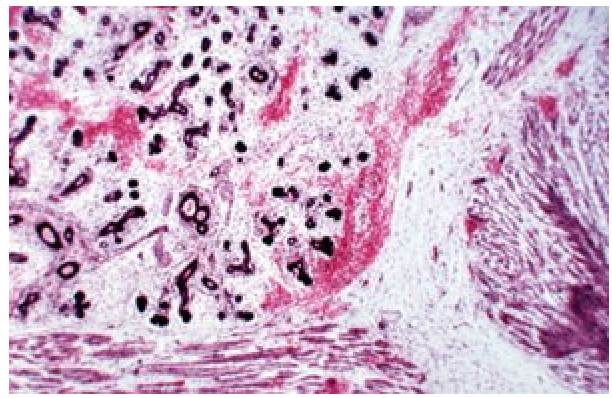
Image 25



High power of image 24.Anlage of a salivary gland. Higher power of image 29. Notice that some of the epithelial cords have become canalized. H & E, 100x

Salivary Gland Development

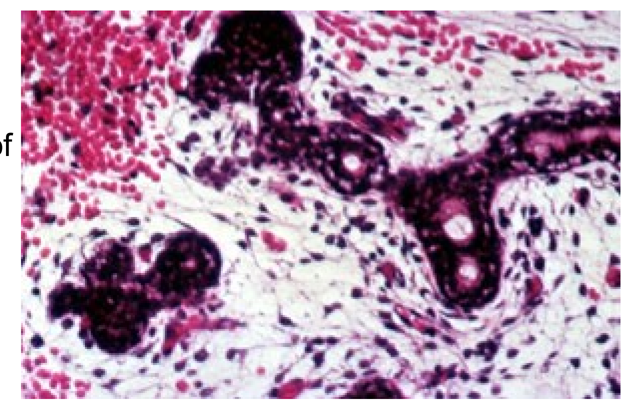
Image 26



Developing parotid gland. Another view of the developing parotid gland. H & E, 100x

Salivary Gland Development

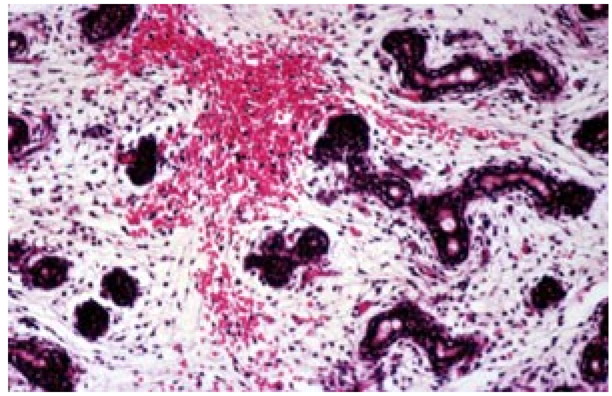
Image 27



Developing parotid gland. Higher power of image 32. H & E, 200x

Salivary Gland Development

Image 28



Developing parotid gland. Observe the deeply stained solid and canalized epithelial cords. H & E, 100x

Odontogenesis

Developmental stages

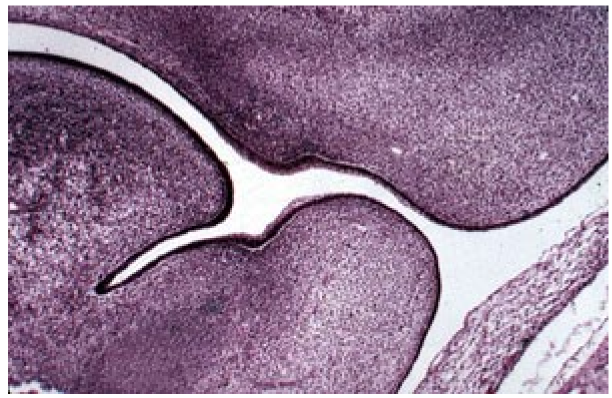
Although tooth development is a continuous process, the developmental history of a tooth is divided into several morphologic “stages “for descriptive purposes. While the size and shape of individual teeth are different, they pass through similar stages of development. They are named after the shape of the epithelial part of the tooth germ and are called the bud, cap, and bell stages.

Dental Lamina

Image 29

Sagittal Section

The dental lamina appears as an epithelial thickening of the oral epithelium adjacent to a condensation of ectomesenchyme. A section of the tongue is at the left border of the slide while the facial opening to the stomodeum is located to the right. H&E, 40x



Dental Lamina

Image 30

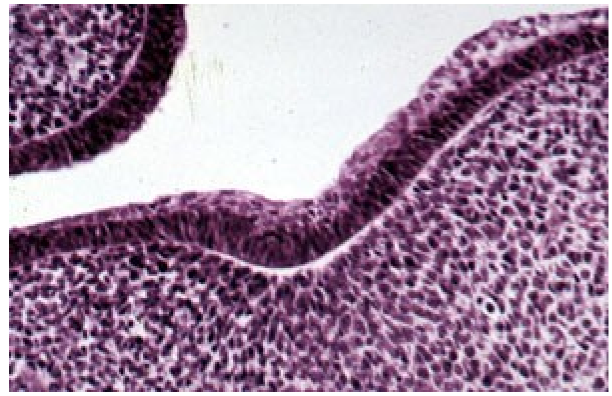
Sagittal Section

Higher power of image 29. The invaginating dental lamina and the ectomesenchyme are seen with better resolution. H&E, 100x

Dental Lamina

Image 31 Sagittal Section

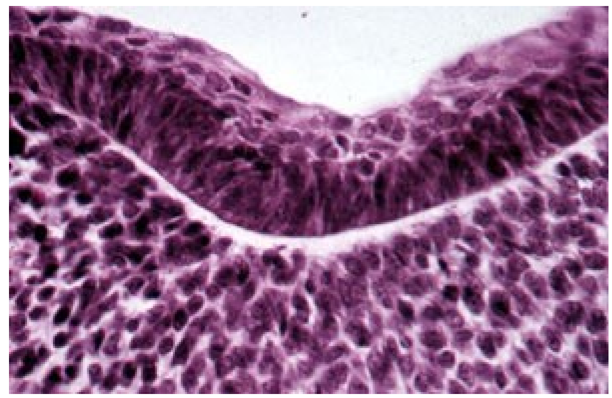
Higher power of image 30. Mandibular dental lamina. H&E, 200x



Dental Lamina

Image 32 Sagittal Section

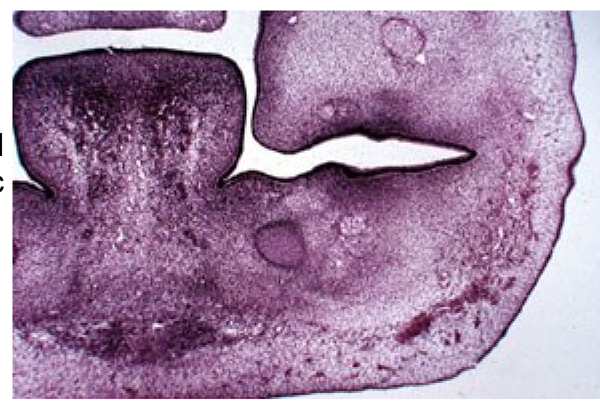
Higher power of image 31. Notice the columnar shape of the basal cells of the dental lamina and the flat shape of the surface cells. H&E, 400x



Dental Lamina

Image 33 Sagittal Section

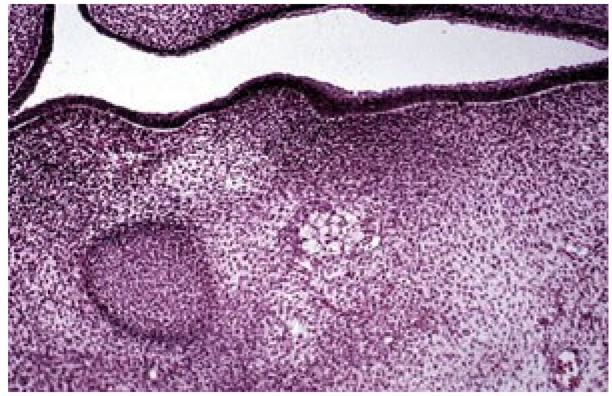
Notice the maxillary and mandibular dental laminae. Review the other embryonic structural features of the frame. H&E, 40x



Dental Lamina

Image 34 Coronal Section

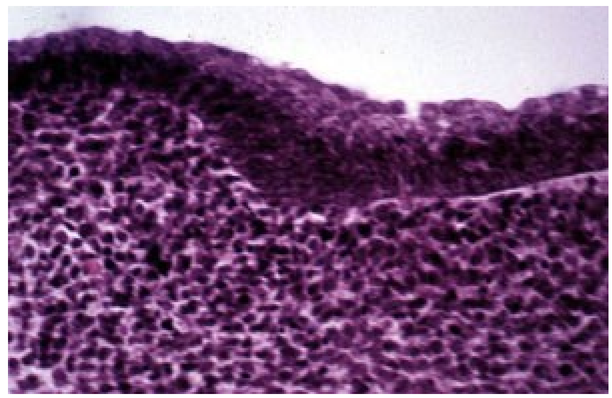
Higher power of image 33.
The photomicrographs display the dental lamina, Meckel's cartilage and the mandibular nerve. H&E, 100x



Dental Lamina

Image 35 Coronal Section

Higher power of image 34. H&E, 400x



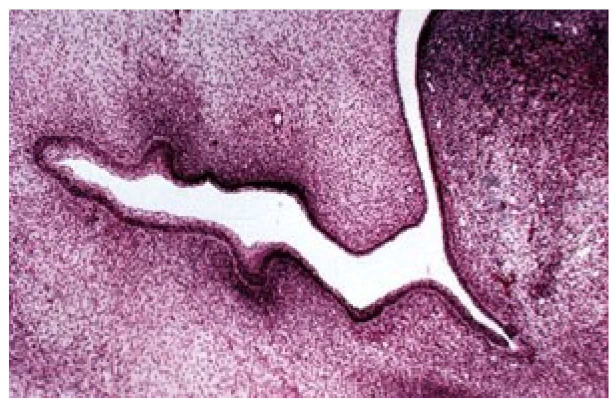
Bud stage

The epithelium of the dental laminae is separated from the underlying ectomesenchyme by a basement membrane. Simultaneous with the differentiation of each dental lamina, round or ovoid swellings arise from the basement membrane at 10 different points, corresponding to the future positions of the deciduous teeth. These are the primordia of the enamel organs. Thus the development of tooth germs is initiated, and the cells continue to proliferate faster than adjacent cells. The dental lamina is shallow, and microscopic sections often show tooth buds close to the oral epithelium. Since the main function of certain epithelial cells of the tooth bud is to form the tooth enamel, these cells constitute the enamel organ, which is critical to normal tooth development. In the bud stage, the enamel organ consists of peripherally located low columnar cells and centrally located polygonal cells. Many cells of the tooth bud and the surrounding mesenchyme undergo mitosis. As a result of the increased mitotic activity and the migration of neural crest cells into the area the ectomesenchymal cells surrounding the tooth bud condense. The area of ectomesenchymal condensation immediately subjacent to the enamel organ is the dental papilla. The condensed ectomesenchyme that surrounds the tooth bud and the dental papilla is the dental sac. Both the dental papilla and the dental sac become more well defined as the enamel organ grows into the cap and bell shapes. The cells of dental papilla will form tooth pulp and dentin. The cells in the dental sac will form cementum and the periodontal ligament.

Bud Stage

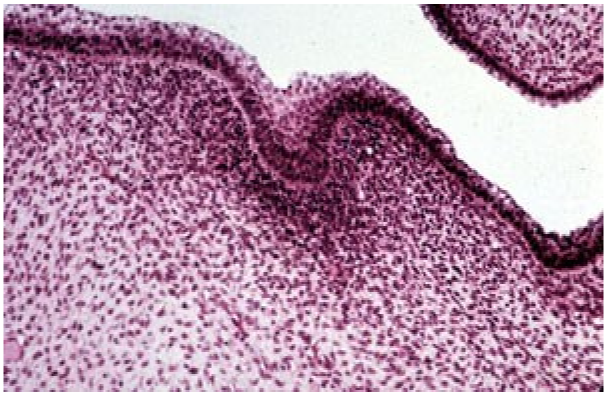
Image 35 Coronal Section

The progressive proliferation of the dental lamina into the ectomesenchyme results in the formation of a tooth bud at the distal end of the dental lamina. H&E, 40x



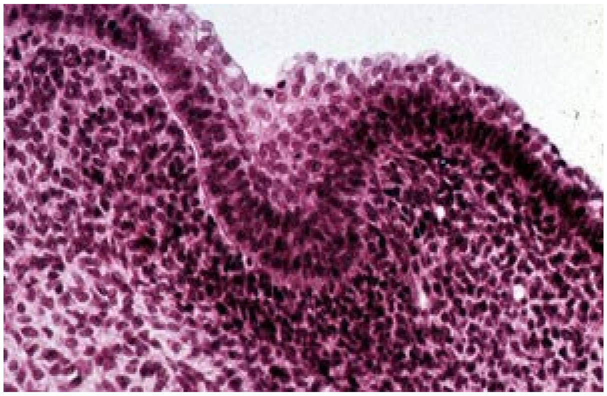
Bud Stage
Image 36
Coronal Section

Higher power of image 35. Mandibular tooth bud. H&E, 100x



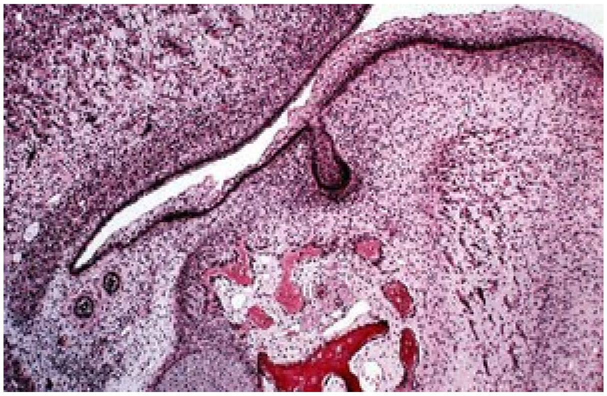
Bud Stage
Image 37 Coronal Section

Higher power of image 36. Mandibular tooth bud. H&E, 200x



Bud Stage
Image 38 Coronal Section

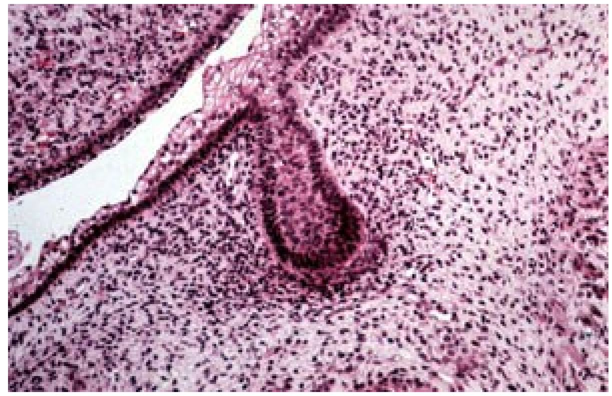
Observe the bud stage, tongue, Meckel's cartilage and the area of intramembranous osteogenesis. H&E, 40x



Bud Stage

Image 39 Coronal Section

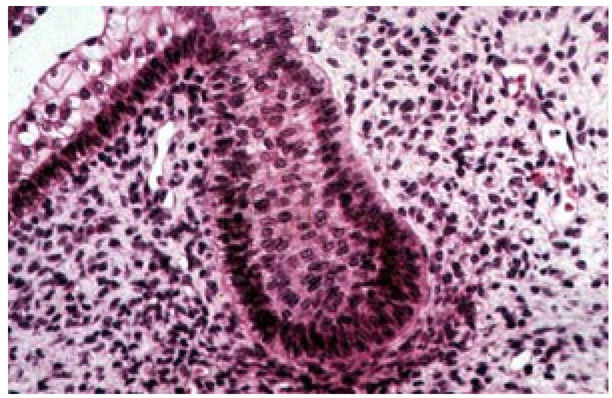
Higher power of image 38. A mandibular tooth bud is connected to the oral epithelium by a short dental lamina. H&E, 100x



Bud Stage

Image 40 Coronal Section

Higher power of image 39. A mandibular tooth bud is connected to the oral epithelium by a short dental lamina. H&E, 200x



Cap stage

As the tooth bud continues to proliferate, it does not expand uniformly into a larger sphere. Instead, unequal growth in different parts of the tooth bud leads to the cap stage, which is characterized by a shallow invagination on the deep surface of the bud.

Outer and inner enamel epithelium

The peripheral cells of the cap stage are cuboidal, cover the convexity of the cap, and are called outer enamel epithelium. The cells in the concavity of the cap become tall, columnar and represent the inner enamel epithelium. The outer enamel epithelium is separated from the dental sac, and the inner enamel epithelium from the dental papilla, by a delicate basement membrane.

Stellate reticulum cell

Polygonal cells located in the center of the epithelial enamel organ, between the outer and inner enamel epithelia, begin to separate as more intercellular fluid is produced and form a cellular network called the stellate reticulum. The cells assume a branched reticular form. The spaces in this reticular network are filled with a mucoid fluid that is rich in albumin, which gives the stellate reticulum a cushion like consistency that may support and protect the delicate enamel forming cells.

The cells in the center of the enamel organ are densely packed and form the enamel knot. This knot projects in part toward the underlying dental papilla, so that the center of the epithelial invagination shows a slightly knoblike enlargement that is bordered by the labial and lingual enamel grooves.

Dental papilla

Under the organizing influence of the proliferating epithelium of the enamel organ, the ectomesenchyme that is partially enclosed by the invaginated portion of the inner enamel epithelium proliferates. It condenses to form the dental papilla, which is the formative organ of the dentin and the primordium of the pulp. The changes in the dental papilla occur concomitantly with the development of the epithelial enamel organ. Although the epithelium exerts a dominating influence over the adjacent connective tissue, the condensation of the latter is not a passive crowding by the proliferating epithelium. The dental papilla shows active budding of capillaries and mitotic figures, and its peripheral cells adjacent to the inner enamel epithelium enlarge and later differentiate into the odontoblasts.

Dental sac

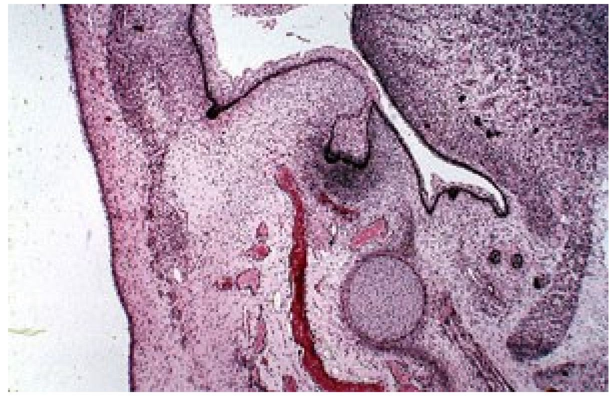
Concomitant with the development of the enamel organ and the dental papilla, there is a marginal condensation in the ectomesenchyme surrounding the enamel organ and dental papilla. Gradually, in this zone, a denser and more fibrous layer develops, which is the primitive dental sac. The cells of the dental sac are important for the formation of cementum and the periodontal ligament.

The epithelial enamel organ, the dental papilla, and the dental sac are the formative tissues for an entire tooth and its supporting structures.

Cap Stage

Image 41 Coronal Section

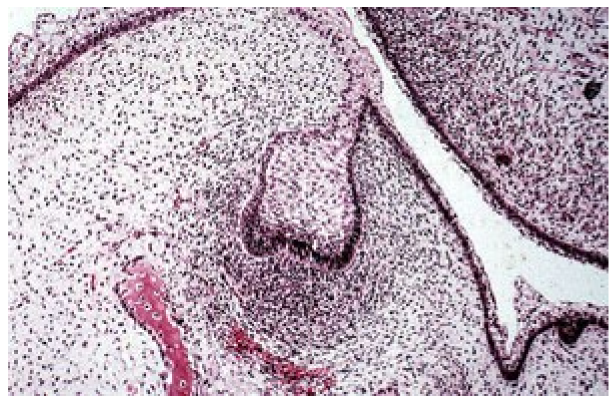
Identify the embryonic structures previously studied. Also identify the cap stage of tooth development. H&E, 40x



Cap Stage

Image 42 Coronal Section

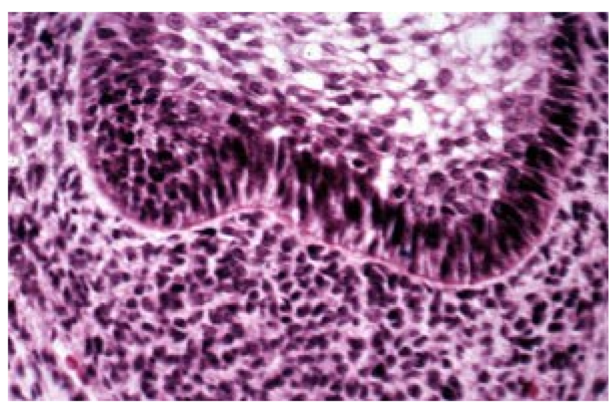
Higher power of image 41. The enamel organ undergoes cytodifferentiation and histodifferentiation in the cap stage of tooth formation. Identify the outer enamel epithelium, inner enamel epithelium, stellate reticulum, cervical loop and the dental lamina. Notice the variations in cell morphology. The concentration of ectomesenchyme, which is in part enveloped by the invaginated inner enamel epithelium, is named the dental papilla. H&E, 100x



Cap Stage

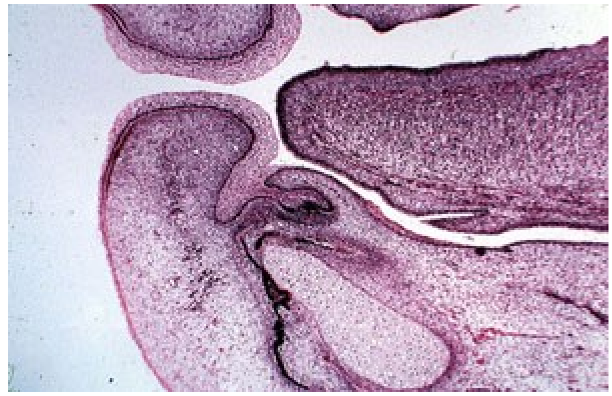
Image 43 Coronal Section

Higher power of image 42. The enamel organ undergoes cytodifferentiation and histodifferentiation in the cap stage of tooth formation. Identify the outer enamel epithelium, inner enamel epithelium, stellate reticulum, and the cervical loop. Notice the variations in cell morphology. The concentration of ectomesenchyme, which is in part enveloped by the invaginated inner enamel epithelium, is named the dental papilla. H&E, 400x



Cap Stage

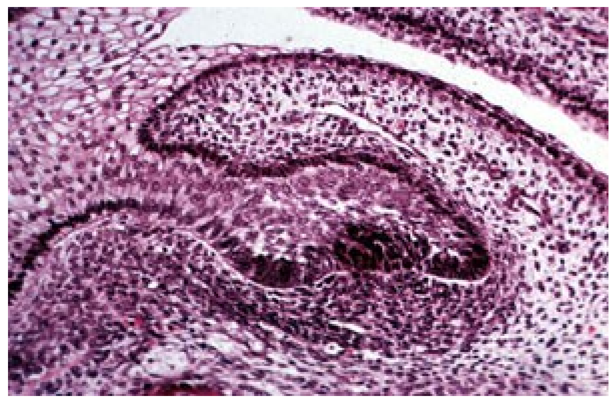
Image 44 Sagittal Section



The tip of the tongue is located in the center of the field adjacent to the upper and lower lips. A cap stage of tooth development is visible in the mandible. Notice Meckel's cartilage and the surrounding intramembranous osteogenesis. H&E, 40x

Cap Stage

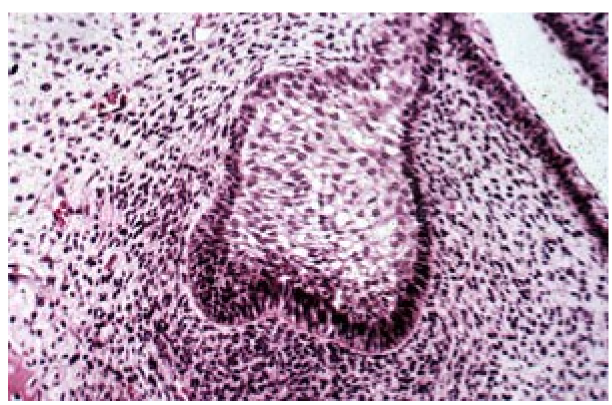
Image 45 Coronal Section



Higher power 0f image 44. Identify the layers of the cap stage of the enamel organ, the dental papilla and the surrounding structures. Notice that the cap is connected, via a dental lamina, to a second epithelial extension from the oral epithelium, the vestibular lamina (lip furrow band). Disintegration of the central cells of the vestibular lamina leads to the formation of the vestibular space located between the lips and cheeks and the alveolar region of the jaws. Notice the structure termed the enamel knot which appears as a densely packed accumulation of cells projecting from the inner enamel epithelium into the dental papilla. H&E, 200x

Cap Stage

Image 46 Coronal Section



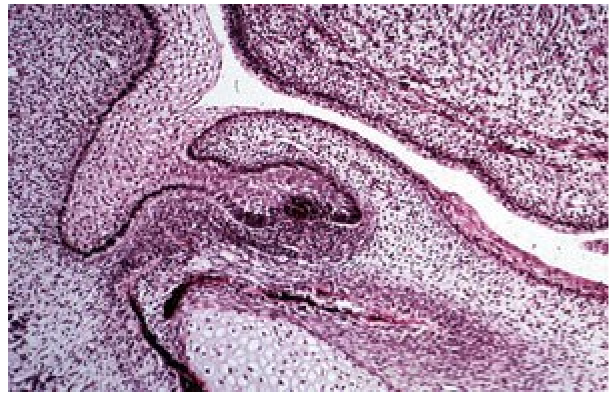
Higher power of image 41. The enamel organ undergoes cytodifferentiation and histodifferentiation in the cap stage of tooth formation. Identify the outer enamel epithelium, inner enamel epithelium, stellate reticulum, cervical loop and the dental lamina. Notice the variations in cell morphology. The concentration of ectomesenchyme, which is in part enveloped by the invaginated inner enamel epithelium, is named the dental papilla. H&E, 100x

Cap Stage

Image 47

Sagittal Section

Higher power of image 44. Identify the layers of the cap stage of the enamel organ, the dental papilla and the surrounding structures. Notice that the cap is connected, via a dental lamina, to a second epithelial extension from the oral epithelium, the vestibular lamina (lip furrow band). Disintegration of the central cells of the vestibular lamina leads to the formation of the vestibular space located between the lips and cheeks and the alveolar region of the jaws. Notice the structure termed the enamel knot which appears as a densely packed accumulation of cells projecting from the inner enamel epithelium into the dental papilla. H&E, 100x

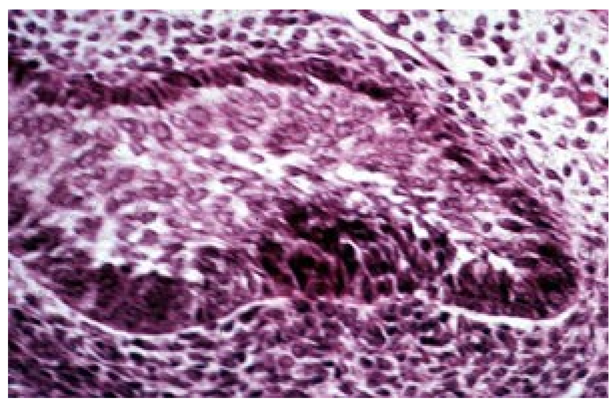


Cap Stage

Image 48

Sagittal Section

Higher power of image 45. Identify the layers of the cap stage of the enamel organ, and the dental papilla. Notice the structure termed the enamel knot which appears as a densely packed accumulation of cells projecting from the inner enamel epithelium into the dental papilla. H&E, 400x



Bell stage

As the invagination of the epithelium depends and its margins continue to grow, the enamel organ assumes a bell shape. Four different types of epithelial cells can be distinguished on light microscopic examination of the bell stage of the enamel organ. The cells form the inner enamel epithelium, the stratum intermedium, the stellate reticulum, and the outer enamel epithelium.

Inner enamel epithelium: The inner enamel epithelium consists of a single layer of cells that differentiate prior to Amelogenesis into tall columnar cells called ameloblasts. These cells are 4 to 5 micrometers in diameter and about 40 micrometers high. These elongated cells are attached to one another by junctional complexes laterally and to cells in the stratum intermedium by desmosomes.

The cells of the inner enamel epithelium exert an organizing influence on the underlying mesenchymal cells in the dental papilla, which later differentiate into odontoblasts.

Stratum intermedium: A few layers of squamous cells form the stratum intermedium, between the inner enamel epithelium and the stellate reticulum. These cells are closely attached by desmosomes and gap junctions. The well-developed cytoplasmic organelles, acid mucopolysaccharides, and glycogen deposits indicate a high degree of metabolic activity. This layer seems to be essential to enamel formation. It is absent in the part of the tooth germ that outlines the root portions of the tooth but does not form enamel.

Stellate reticulum: The stellate reticulum expands further, mainly by an increase in the amount of intercellular fluid. The cells are star shaped, with long processes that anastomose with those of adjacent cells. Before enamel formation begins, the stellate reticulum collapses, reducing the distance between the centrally situated ameloblasts and the nutrient capillaries near the outer enamel epithelium. Its cells then are hardly distinguishable from those of the stratum intermedium. The change begins at the height of the cusp or the incisal edge and progresses cervically.

Outer enamel epithelium: The cells of outer enamel epithelium flatten to a low cuboidal form. At the end of the bell stage, preparatory to and during the formation of enamel, the formerly smooth surface of the outer enamel epithelium is laid in folds. Between the folds the adjacent mesenchyme of the dental sac forms papillae that contain capillary loops and thus provide a rich nutritional supply for the intense metabolic activity of the avascular enamel organ.

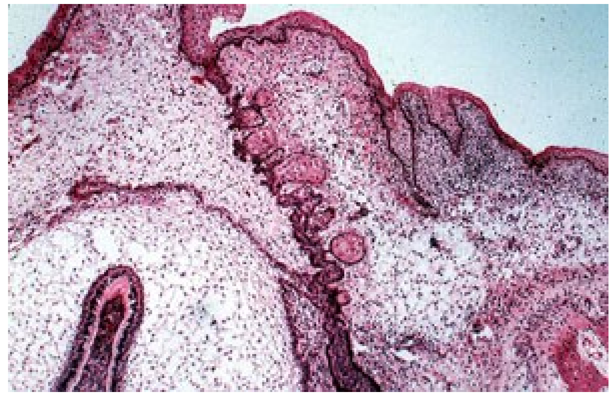
Dental papilla: The dental papilla is enclosed in the invaginated portion of the enamel organ. Before the inner enamel epithelium begins to produce enamel, the peripheral cells of the mesenchymal dental papilla differentiate into odontoblasts under the organizing influence of the epithelium. First, they assume a cuboidal form; later they assume a columnar form and acquire the specific potential to produce dentin.

The basement membrane that separates the enamel organ and the dental papilla just prior to dentin formation is called the membrane preformativa.

Dental sac: Before formation of dental tissues begins, the dental sac shows a circular arrangement of its fibers and resembles a capsular structure. With the development of the root, the fibers of the dental sac differentiate into the periodontal fibers that become embedded in the developing cementum and alveolar bone.

The Bell Stage

Image 49



Notice that an invasion of mesenchymal tissue coincides with the disruption of the dental lamina. H&E, 40x

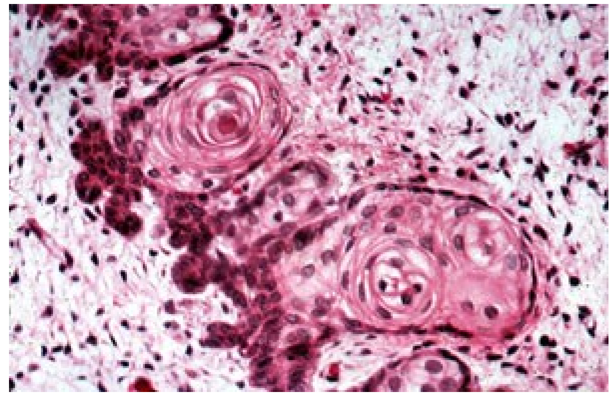
The Bell Stage

Image 50

With continuing proliferation and differentiation of the tooth germ, the enamel organ assumes the shape of a bell which envelops the dental papilla. A new layer of cells termed the stratum intermedium appears between the inner enamel epithelium and the stellate reticulum. A dental lamina connects the outer enamel epithelium of the enamel organ to the oral epithelium. The distal end of the proliferating dental lamina forms the anlage of the permanent tooth, the so-called successional lamina. The third component of the tooth germ is the dental sac which is a concentration of mesenchymal connective tissue that encircles the enamel organ and the dental papilla. H&E, 30x

The Bell Stage
Image 51

Higher power of image 49. Epithelial pearl formations are evident in the regressing dental lamina. H&E, 200x

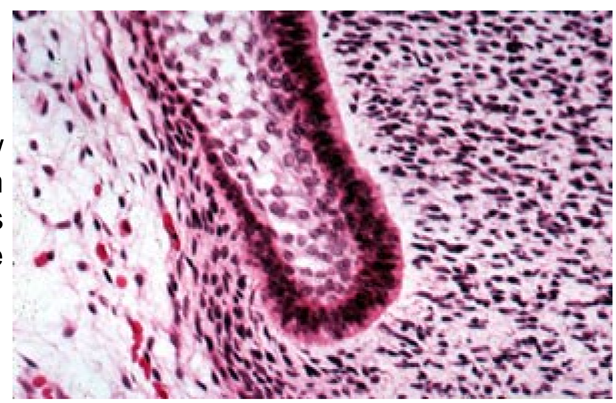


The Bell Stage
Image 52

Identify the three parts of the tooth germ and the four layers of the enamel organ. H&E, 40x

The Bell Stage
Image 53

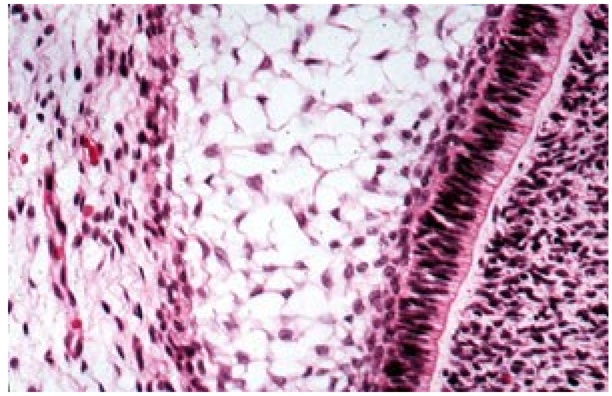
Higher power of image 52. The layer of low columnar cells of the inner enamel epithelium is continuous with the layer of cuboidal cells that form the outer enamel epithelium at the structure termed the cervical loop. H&E, 200x



The Bell Stage

Image 54

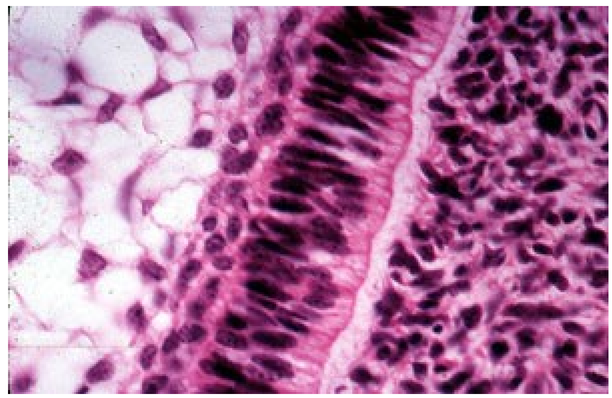
Higher power of image 52. Scanning from left to right, identify the dental sac, outer enamel epithelium, stellate reticulum, stratum intermedium, inner enamel epithelium and the dental papilla. H&E, 200x



The Bell Stage

Image 55

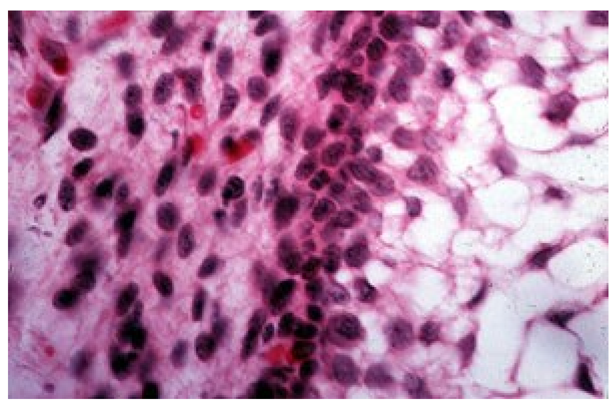
Higher power of image 54. Identify the star-shaped cells of the stellate reticulum, the flat cells of the stratum intermedium, the tall columnar cells of the inner enamel epithelium and the dental papilla. H&E, 400x



The Bell Stage

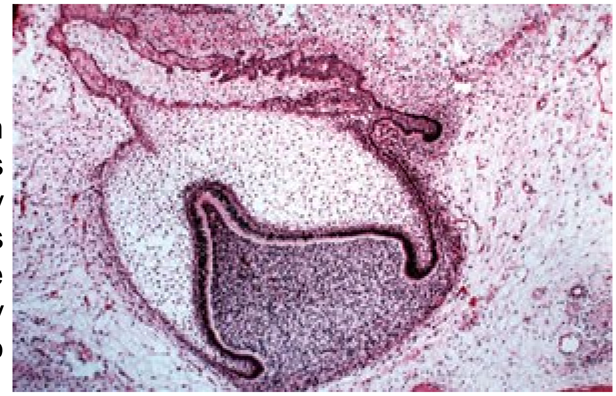
Image 56

Higher power of image 54. The dental sac which is supplied with blood vessels is positioned on one side of the outer enamel epithelium and the mucoid-filled stellate reticulum is on the opposite side. H&E, 400x



The Bell Stage

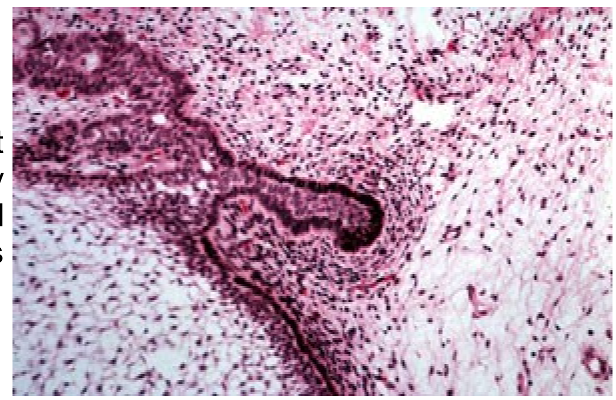
Image 57



Identify the histologic features of the tooth germ that you have studied in previous frames. Two additional structures to identify are the lateral dental lamina which extends from the dental lamina proper to the top of the bell and the enamel niche which is presumably formed by the migration of mesenchyme into the dental lamina. H&E, 40x

The Bell Stage

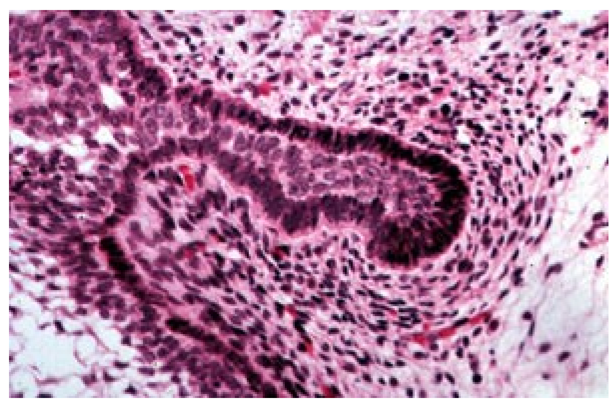
Image 58



Higher power of image 57. The permanent tooth bud (successional lamina) is formed by the proliferation of the dental lamina toward the lingual or palatal side of the deciduous tooth germ. H&E, 100x

The Bell Stage

Image 59

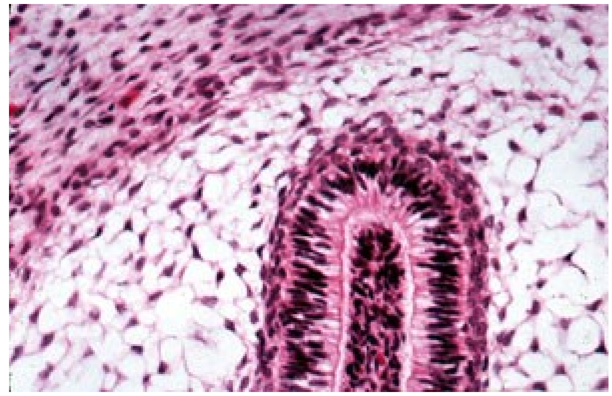


Higher power of image 58. H&E, 200x

The Bell Stage

Image 60

Higher power of image 52. The layers of the tooth germ are shown as they appear at the top of the bell. H&E, 200x



The Bell Stage

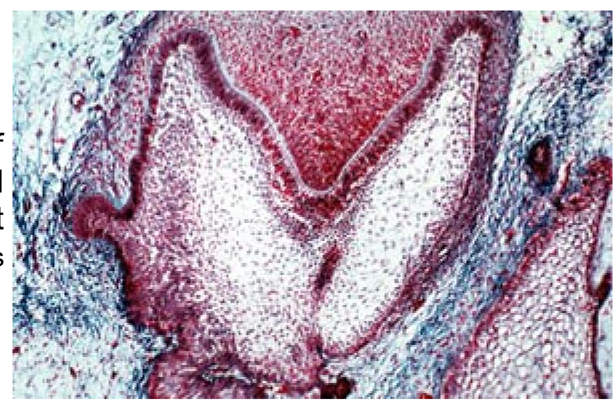
Image 61

Review the histologic features of the tooth germ and its associated structures. Notice that an incisive canal is located on the left and the upper lip on the right side of the photomicrograph, respectively. Mallory's Trichrome, 30x

The Bell Stage

Image 62

Higher power of image 61. A linear group of cells collectively termed the enamel cord traverses the stellate reticulum. It is a transient structure with no known function. Mallory's Trichrome, 100x



Dentinogenesis & Amelogenesis

Dentinogenesis

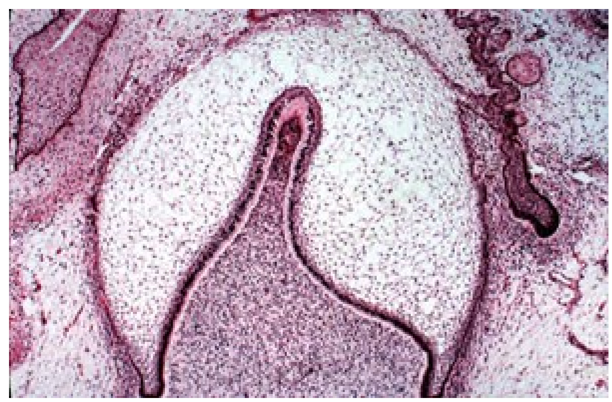
Dentin is the first formed of the dental hard tissues and dentinogenesis begins at the late stage of tooth development at the cusp tips after the odontoblasts differentiated and begin collagen production. Dentinogenesis is a two-phase sequence in that collagen matrix is first formed and then calcified. As each increment of predentin is formed along the pulp border, it remains a day before it is calcified and the next increment of predentin forms. Von Korff's Fibers have been described as the initial dentin deposition along the cusp tips.

The mineralization sequence in dentin appears to be as follows. The earliest crystal deposition is in the form of very fine plates of hydroxyapatite on the surfaces of the collagen fibrils and in the ground substance. Subsequently, crystals are laid down within the fibrils themselves. The crystals associated with the collagen fibrils are arranged in an orderly fashion, with their long axes paralleling the fibril long axes. The general calcification process is gradual, but the peritubular region becomes highly mineralized at a very early stage.

Dentinogenesis

Image 63

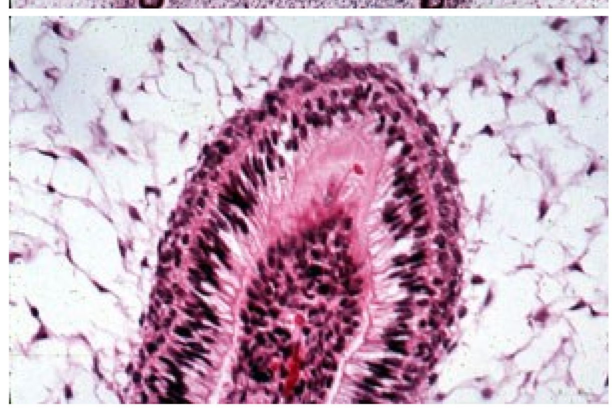
Incipient dentinogenesis is shown at the cuspal region of the dental pulp. H&E, 40x



Dentinogenesis

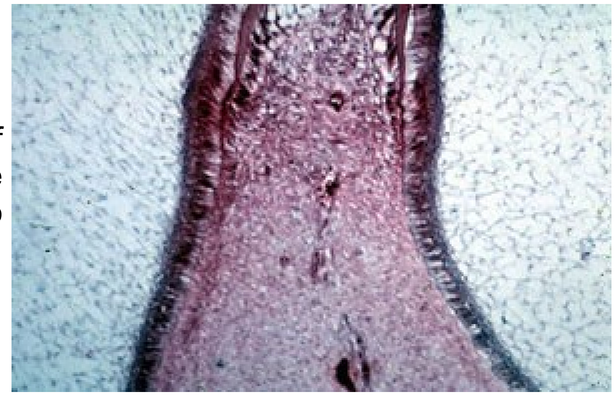
Image 64

Higher power of image 63. Notice the thin layer of eosinophilic predentin which has been formed between the columnar-shaped odontoblasts and preameloblasts. H&E, 200x



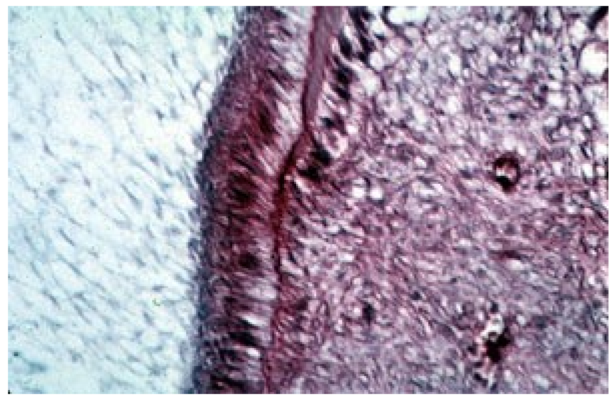
Von Korff's Fibers
Image 65

Observe the corkscrew-shaped appearance of von Korff's fibers which spiral between the odontoblasts and become incorporated into the layer of predentin. Soule's Gold Chloride, 100x



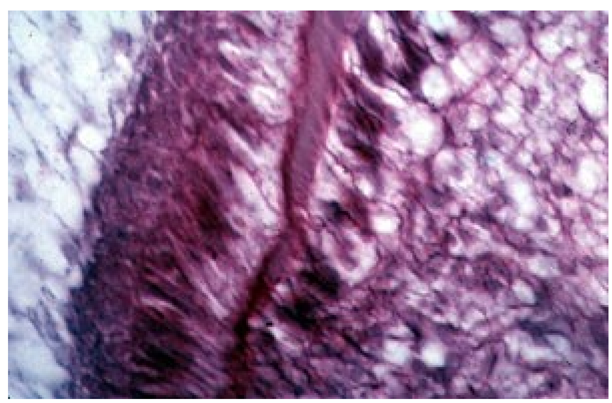
Von Korff's Fibers
Image 66

Higher power of image 65.Observe the corkscrew-shaped appearance of von Korff's fibers which spiral between the odontoblasts and become incorporated into the layer of predentin. Soule's Gold Chloride, 200x



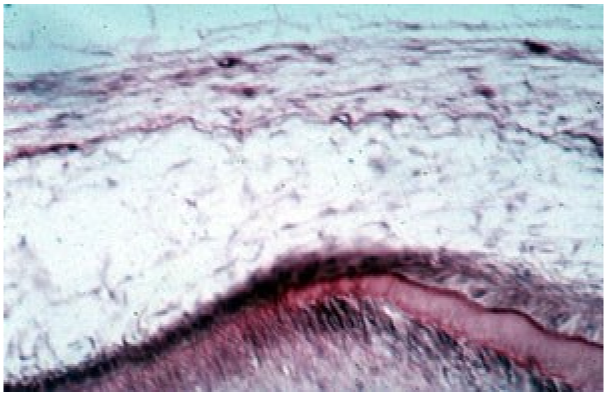
Von Korff's Fibers
Image 67

Higher power of image 66.Observe the corkscrew-shaped appearance of von Korff's fibers which spiral between the odontoblasts and become incorporated into the layer of predentin. Soule's Gold Chloride, 400x



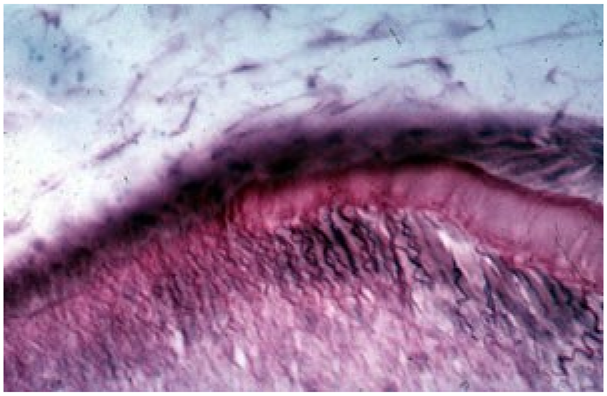
Von Korff's Fibers
Image 68

Von Korff's fibers and a layer of predentin are well illustrated in this photomicrograph. Soule's Gold Chloride, 200x



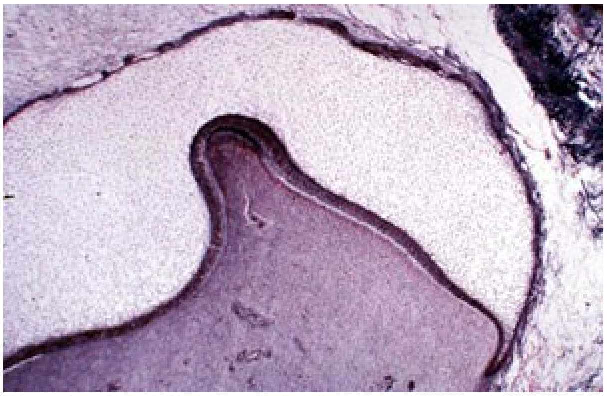
Von Korff's Fibers
Image 69

Von Korff's fibers and a layer of predentin are well illustrated in this photomicrograph. Soule's Gold Chloride, 400x



Dentinogenesis
Image 70

Predentin appears as a homogeneous blue-stained layer that separates the secreting odontoblasts from the differentiating ameloblasts. Mallory's Trichrome, 40x



Dentinogenesis

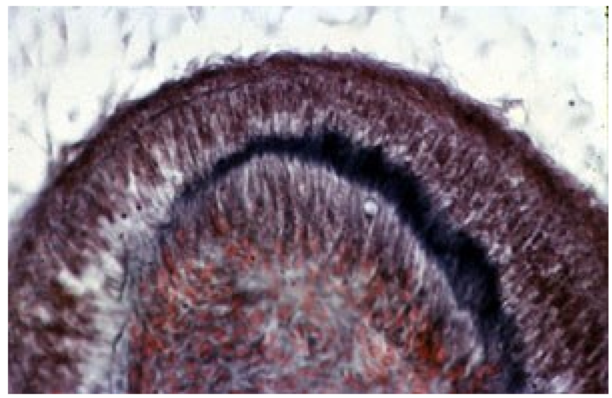
Image 71

Higher power of image 70.Predentin appears as a homogeneous blue-stained layer that separates the secreting odontoblasts from the differentiating ameloblasts. Mallory's Trichrome, 100x

Dentinogenesis

Image 72

Higher power of image 71.Predentin appears as a homogeneous blue-stained layer that separates the secreting odontoblasts from the differentiating ameloblasts. Mallory's Trichrome, 200x



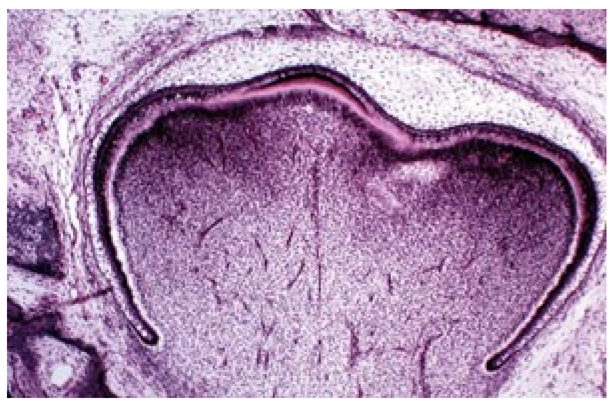
Amelogenesis

The deposition of enamel begins at the late bell stage, immediately after dentinogenesis has commenced. Although differentiated before the odontoblasts (and supplying the message to determine their differentiation), the ameloblasts require the signal of dentin formation to initiate their secretory activities. Amelogenesis consists of three main phases:

- Presecretory, when the cells differentiate in cohorts of similar chronological age and align themselves into rows with older cells cuspally and younger cells cervically.
- Secretory, when the rows of ameloblasts retreat from the dentin in unison and lay down enamel. The enamel is laid down mineralized with no pre-enamel layer analogous to predentin. The whole cell retreats and no process is left embedded in the matrix. The matrix begins to degrade at this stage and starts to be replaced by water.
- Maturation, when the full thickness of enamel has been formed and is morphologically complete. The remaining protein and water are removed and mineral ions added. Growing crystals in turn displace the water, resulting in fully calcified, native enamel.

Dentinogenesis & Amelogenesis

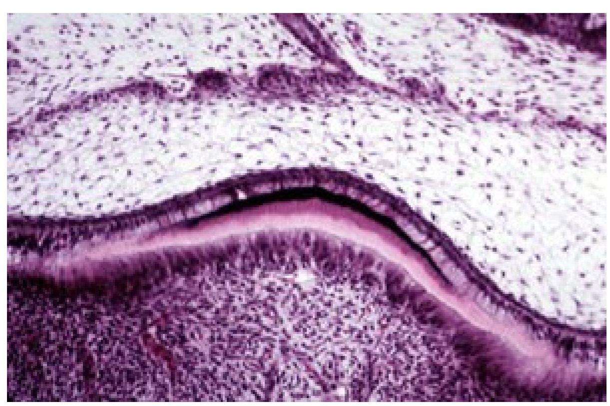
Image 73



A layer of predentin is stained a pale pink, mineralized dentin a dark pink and enamel matrix a deep blue. Notice that apposition of the dental hard tissues always proceeds from the occlusal or incisal region toward the cervical region of the crown. H&E, 40x

Dentinogenesis & Amelogenesis

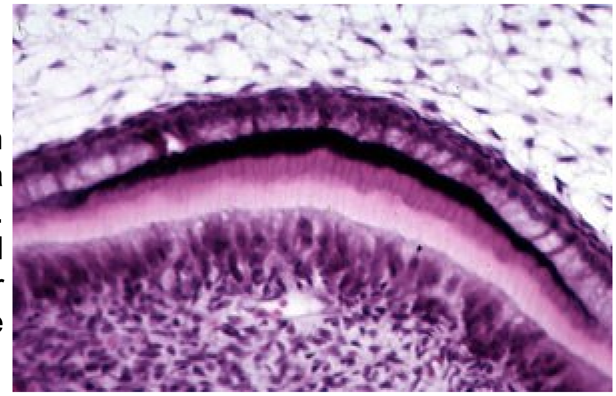
Image 74



Higher power of image 73. A layer of predentin is stained a pale pink, mineralized dentin a dark pink and enamel matrix a deep blue. Notice that apposition of the dental hard tissues always proceeds from the occlusal or incisal region toward the cervical region of the crown. H&E, 100x

Dentinogenesis & Amelogenesis

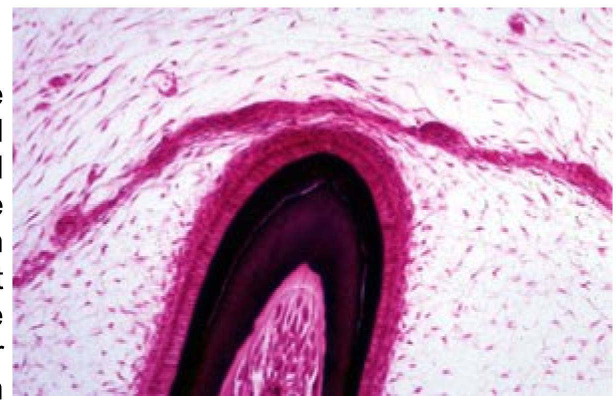
Image 75



Higher power of image 74. A layer of predentin is stained a pale pink, mineralized dentin a dark pink and enamel matrix a deep blue. Notice that apposition of the dental hard tissues always proceeds from the occlusal or incisal region toward the cervical region of the crown. H&E, 200x

Apposition of Dentin & Enamel

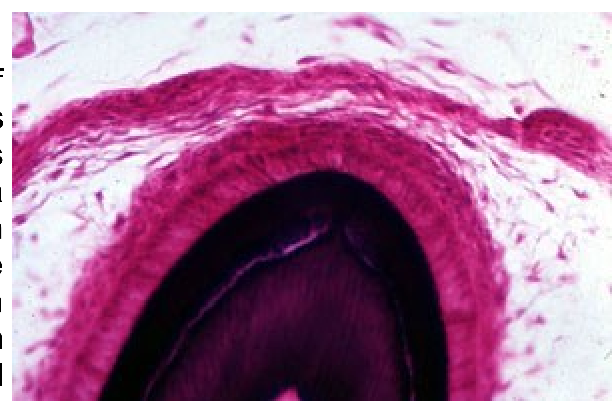
Image 76



A thin layer of predentin adjacent to the odontoblasts is stained pink, mineralized dentin appears medium blue and enamel matrix is stained a dark blue. Notice the artifactitious separation between the dentin and enamel at the dentinoenamel junction. At the cuspal region of the developing tooth the stellate reticulum has regressed and the outer enamel epithelium is juxtaposed to the stratum intermedium. H&E, 100x

Apposition of Dentin & Enamel

Image 77

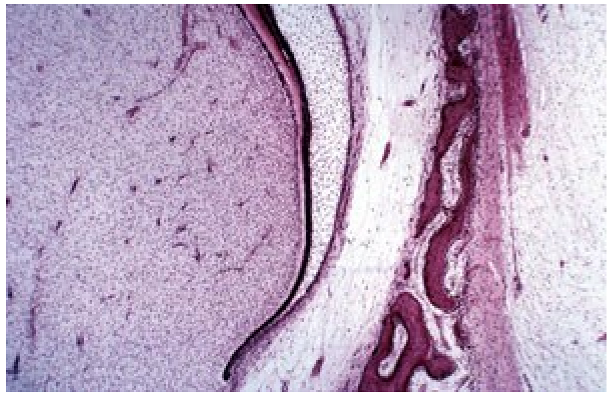


Higher power of image 76. A thin layer of predentin adjacent to the odontoblasts is stained pink, mineralized dentin appears medium blue and enamel matrix is stained a dark blue. Notice the artifactitious separation between the dentin and enamel at the dentinoenamel junction. At the cuspal region of the developing tooth the stellate reticulum has regressed and the outer enamel epithelium is juxtaposed to the stratum intermedium. H&E, 200x

Apposition of Dentin & Enamel

Image 78

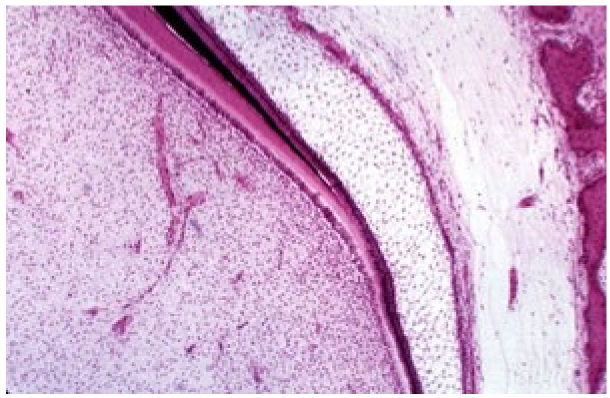
Apposition of dentin and enamel at the cervical region of the developing crown. H&E, 40x



Apposition of Dentin & Enamel

Image 79

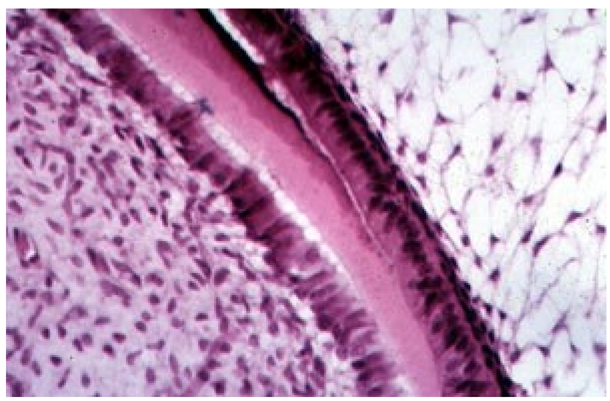
Area of dentin and enamel formation coronal to image 58. Identify in sequence the hard and soft tissue layers of the developing tooth crown. H&E, 40x



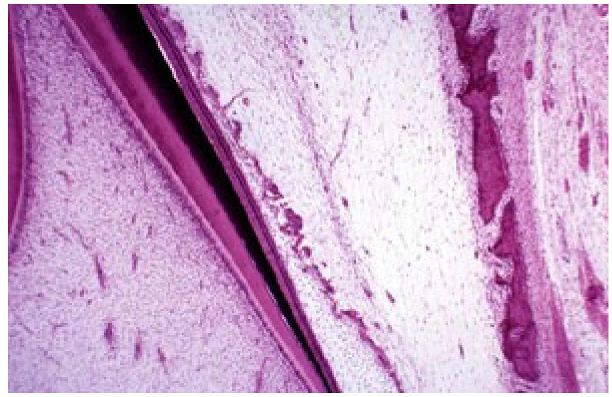
Apposition of Dentin & Enamel

Image 80

Higher power of image 79. Area of dentin and enamel formation coronal to image 58. Identify in sequence the hard and soft tissue layers of the developing tooth crown. H&E, 200x

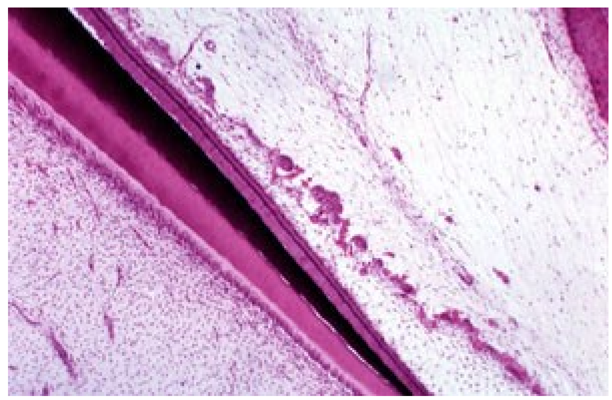


Advanced Stage of Apposition
Image 81



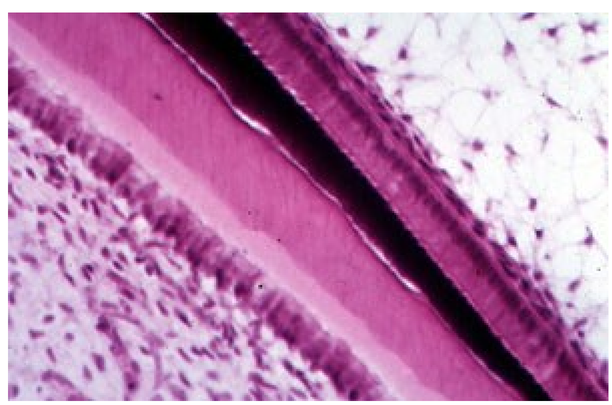
The dental pulp is situated on the left and a portion of the dental sac and bony crypt on the right areas of the frame, respectively. Identify the dental pulp, odontoblast layer, predentin, dentin, enamel, ameloblast layer, stratum intermedium, stellate reticulum and the outer enamel epithelium. Notice that the outer enamel epithelium is positioned next to the stratum intermedium in areas of more advanced apposition. H&E, 30x

Advanced Stage of Apposition
Image 82



The dental pulp is situated on the left and a portion of the dental sac and bony crypt on the right areas of the frame, respectively. Identify the dental pulp, odontoblast layer, predentin, dentin, enamel, ameloblast layer, stratum intermedium, stellate reticulum and the outer enamel epithelium. Notice that the outer enamel epithelium is positioned next to the stratum intermedium in areas of more advanced apposition. H&E, 40x

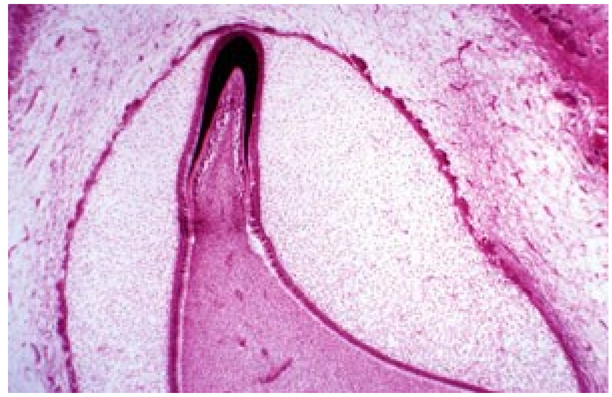
Advanced Stage of Apposition
Image 83



Higher power of image 82. H&E, 200x

Apposition of Dentin & Enamel

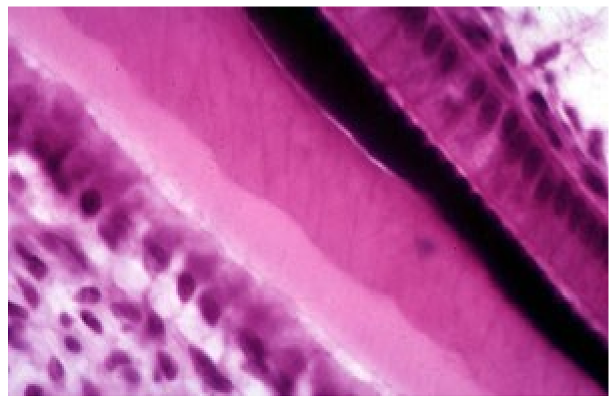
Image 84



A thin layer of predentin adjacent to the odontoblasts is stained pink, mineralized dentin appears medium blue and enamel matrix is stained a dark blue. Notice the artifactitious separation between the dentin and enamel at the dentinoenamel junction. At the cuspal region of the developing tooth the stellate reticulum has regressed and the outer enamel epithelium is juxtaposed to the stratum intermedium. H&E, 40x

Advanced Stage of Apposition

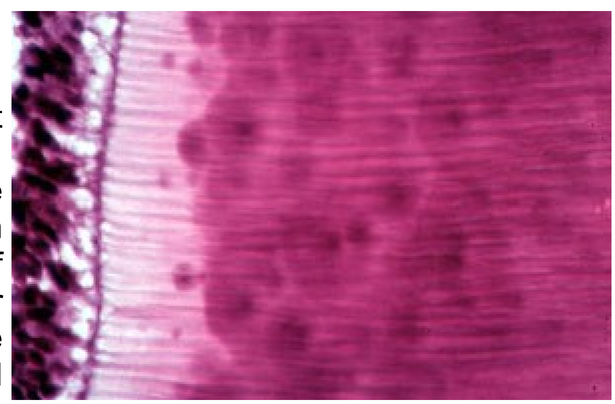
Image 85



Higher power of image 84. In greater detail. H&E, 400x

Dentinogenesis

Image 86

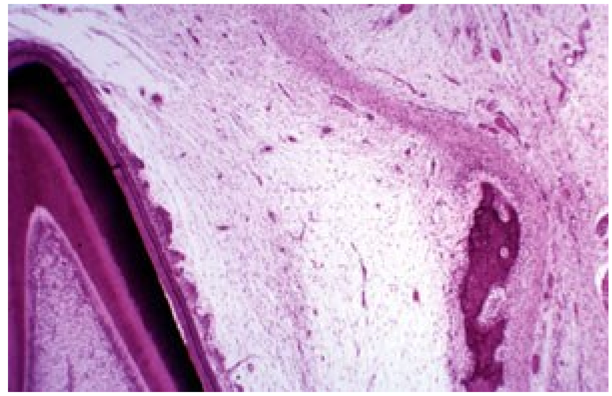


Higher power of image 85. Scanning from left to right, identify the layer of odontoblasts, predentin and dentin. Observe the odontoblastic processes which extend from the odontoblasts into the dentinal tubules of the hard tissue. Also note the areas of globular calcification which form calcospherites at the mineralization front between predentin and dentin. H&E, 400x

Amelogenesis & Dentinogenesis

Image 87

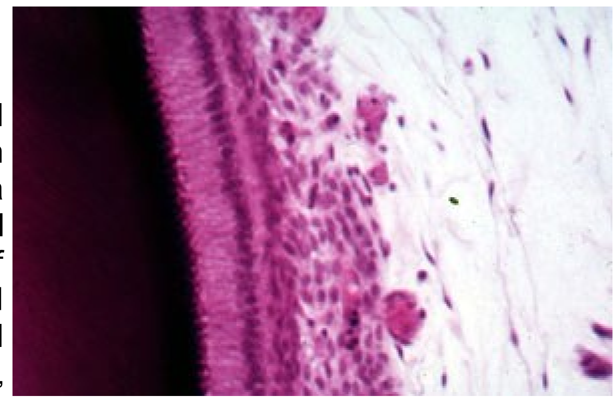
Area of dentin and enamel deposition. H&E, 40x



Amelogenesis

Image 88

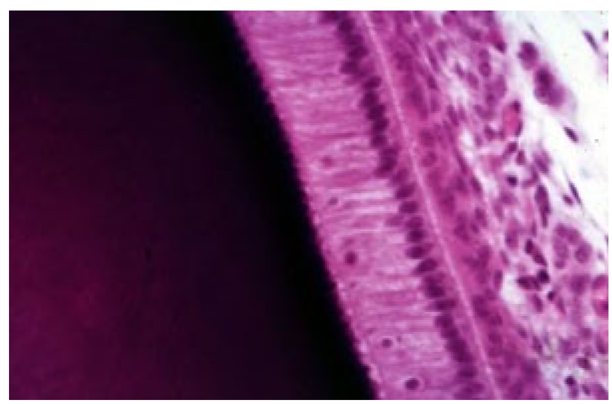
Higher power of image 87. The outer enamel epithelium has joined with the stratum intermedium and ameloblast layers to form a combined layer named the united enamel epithelium. Take note of the blood vessels of the dental sac which are abutting on the united enamel epithelium layer. What is the functional correlation of this structural arrangement? H&E, 200x



Amelogenesis

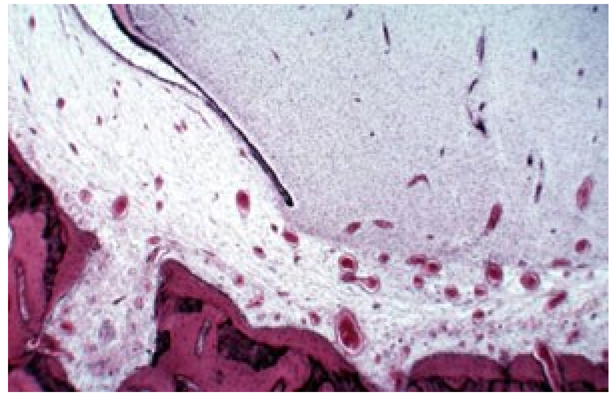
Image 89

Higher power of image 88. Examine the ameloblasts more closely and identify Tomes' processes. H&E, 400x



Hertwig's Epithelial Root Sheath

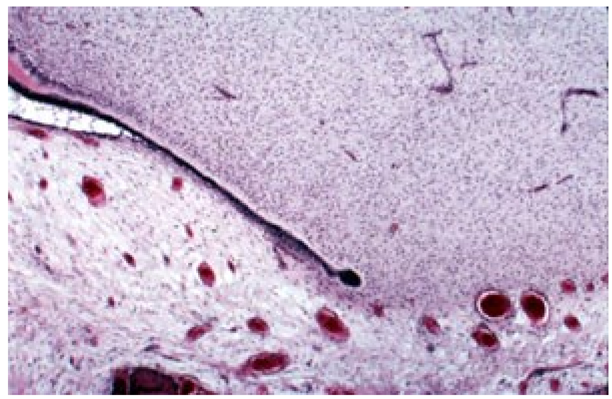
Image 90



As the crown portion of the tooth nears completion, the outer enamel epithelium and the inner enamel epithelium combine at the cervical loop region to form a bilayered structure termed Hertwig's epithelial root sheath. Hertwig's root sheath determines the number, size and shape of roots and is presumably the inductor of dentin formation in the developing root. H&E, 30x

Hertwig's Epithelial Root Sheath

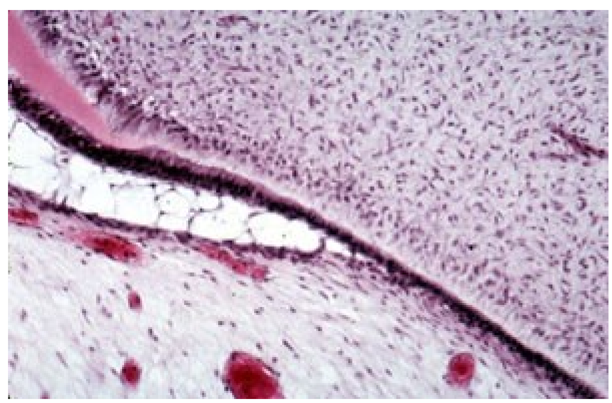
Image 91



As the crown portion of the tooth nears completion, the outer enamel epithelium and the inner enamel epithelium combine at the cervical loop region to form a bilayered structure termed Hertwig's epithelial root sheath. Hertwig's root sheath determines the number, size and shape of roots and is presumably the inductor of dentin formation in the developing root. H&E, 40x

Hertwig's Epithelial Root Sheath

Image 92

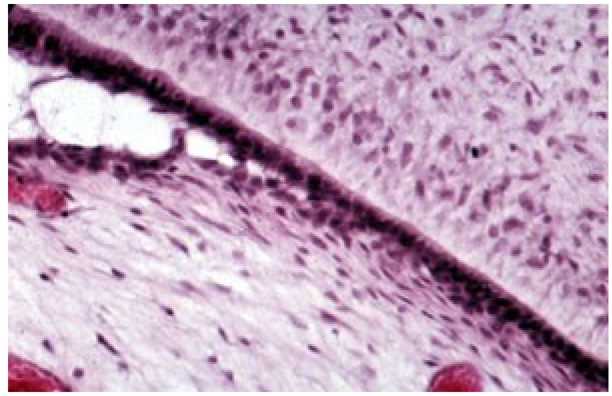


Higher power of image 91. As the crown portion of the tooth nears completion, the outer enamel epithelium and the inner enamel epithelium combine at the cervical loop region to form a bilayered structure termed Hertwig's epithelial root sheath. Hertwig's root sheath determines the number, size and shape of roots and is presumably the inductor of dentin formation in the developing root. H&E, 100x

Hertwig's Epithelial Root Sheath

Image 93

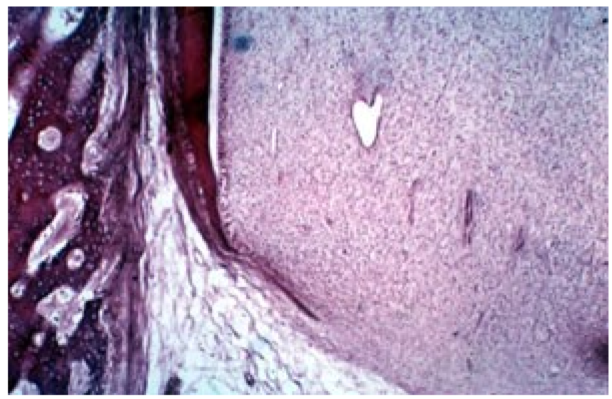
Higher power of image 92. As the crown portion of the tooth nears completion, the outer enamel epithelium and the inner enamel epithelium combine at the cervical loop region to form a bilayered structure termed Hertwig's epithelial root sheath. Hertwig's root sheath determines the number, size and shape of roots and is presumably the inductor of dentin formation in the developing root. H&E, 200x



Hertwig's Epithelial Root Sheath

Image 94

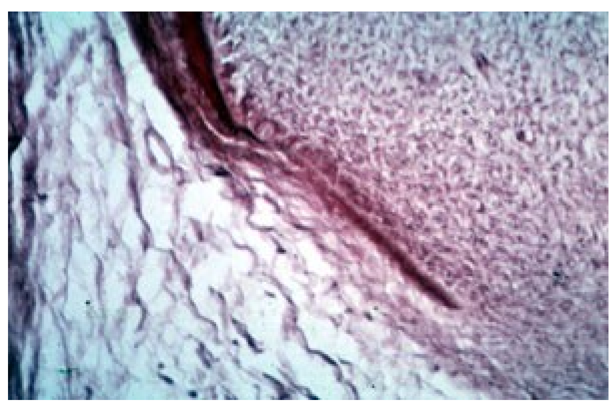
Hertwig's epithelial root sheath at an advanced stage of root formation. H&E, 40x



Hertwig's Epithelial Root Sheath

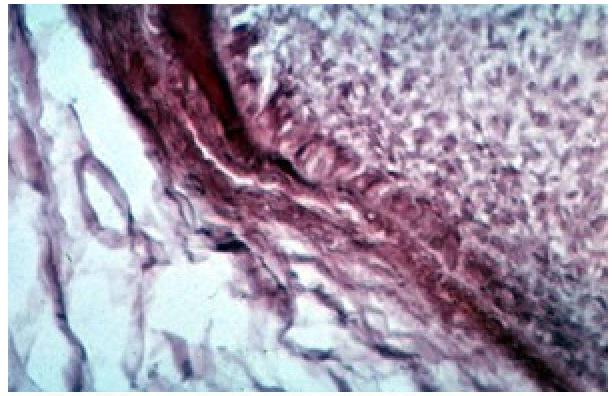
Image 95

Higher power of image 94. Hertwig's epithelial root sheath at an advanced stage of root formation. H&E, 100x



Hertwig's Epithelial Root Sheath

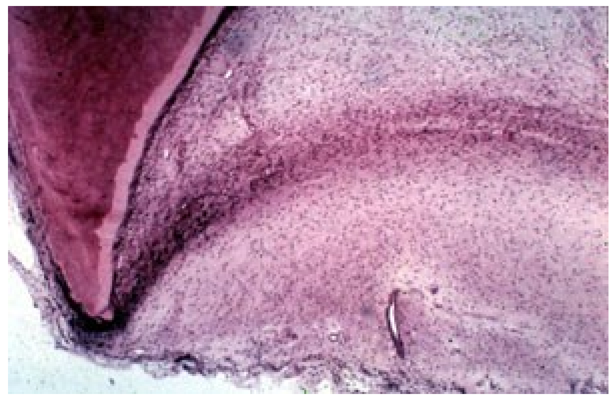
Image 96



Higher power of image 95. Hertwig's epithelial root sheath at an advanced stage of root formation. H&E, 200x

Root Apex

Image 97

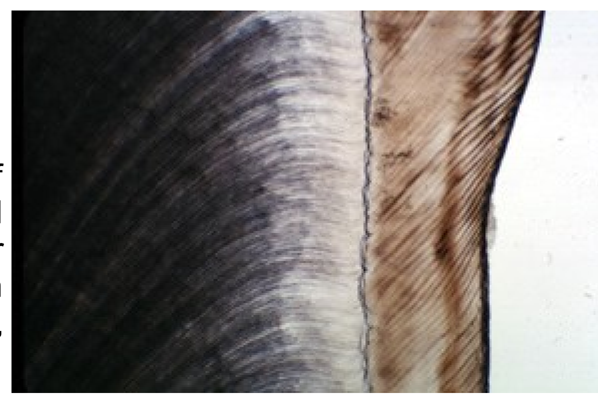


Observe the wide open apical foramen and the taper of the dentinal wall of this incompletely formed root. H&E, 40x

Dentinoenamel Junction

Image 98

Ground Section



Enamel tissue with incremental lines of Retzius and dentin tissue with parallel, curved dentinal tubules are in contact at the irregular dentino-enamel junction. The junction often has a scalloped-shaped morphology. Unstained, 40x

Enamel

Dental enamel covers the anatomical crown of the tooth. It meets the dentin at the dentino-enamel junction, and the cementum at the cervical margin or cemento-enamel junction. The thickness of enamel varies according to location. It is thickest over the incisal edge and cusps (about 2 to 2.5 mm), and thins to a knife-edge at the cervical margin.

Physical properties

Enamel is the hardest calcified tissue in the human body, rendering the teeth suitable for mastication. It act in a sense like semipermeable membrane, permitting complete or partial passage of certain molecules. The color of enamel-covered crown ranges from yellowish white to grayish white. The structure and hardness of the enamel render it brittle, which is particularly apparent when the enamel loses its foundation of sound dentin. The specific gravity of enamel is 2.8.

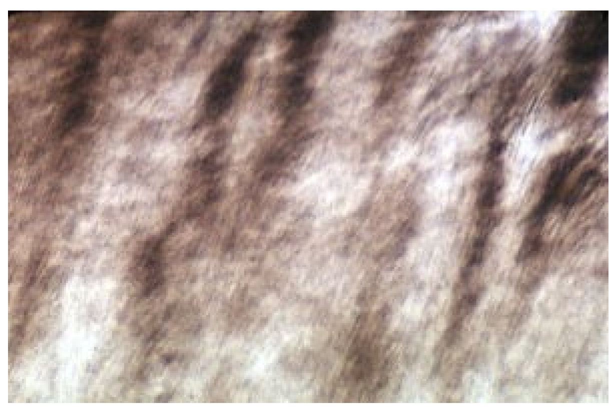
Chemical properties

Mature enamel is highly mineralized. It contains by weight 96% inorganic material, 1% organic material and 3% water (89%, 2%, 9% by volume). The inorganic component is mainly calcium phosphate in the form of hydroxyapatite crystals. Small amounts of carbonate, magnesium, potassium, sodium and fluoride are also present.

Two groups of proteins are found in developing enamel: the unique amelogenins (which are well characterized), and much smaller amounts of non-amelogenins (often collectively known as enamelins). The amelogenins are removed during the enamel development, although small amounts persist in the fully formed tissue. The enamel proteins do not appear to be fibrous and they may form a relatively structureless gel. The presence of other organic elements such as lipids is controversial.

Enamel

Image 99 Ground Section



Higher power of image 98. Curved enamel prisms which are present in successive layers of enamel appear to intertwine. In some areas of the enamel, rod striations are visible in the enamel rods. The enamel rods are oriented vertically in the photomicrograph. Unstained, 100x

Enamel

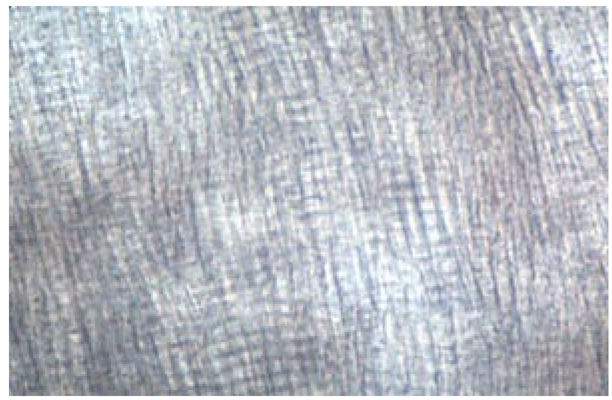
Image 100 Ground Section

Curved enamel prisms which are present in successive layers of enamel appear to intertwine. In some areas of the enamel, rod striations are visible in the enamel rods. The enamel rods are oriented vertically in the photomicrograph. Unstained, 100x

Enamel

Image 101 Ground Section

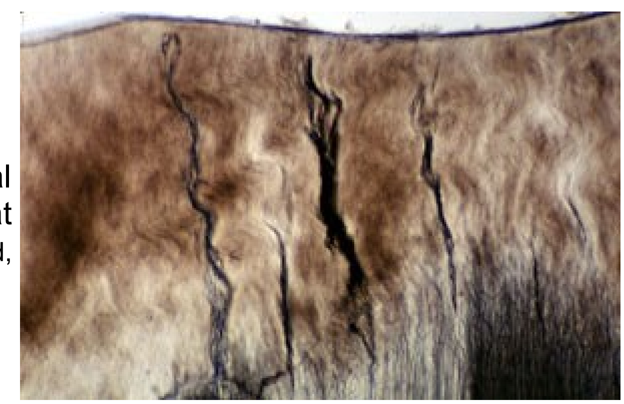
Higher power of image 100. The rod striations of the enamel prisms are more evident at this magnification. Unstained, 400x



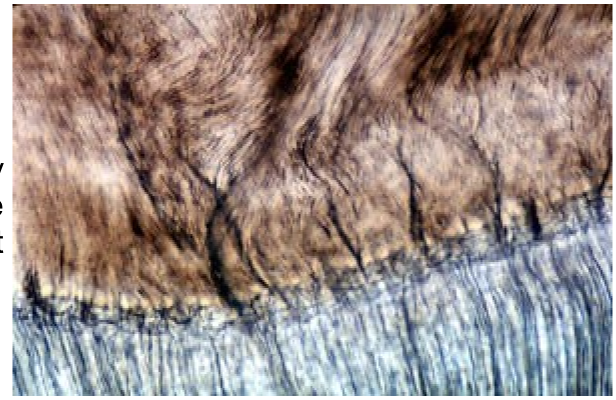
Enamel Lamellae

Image 102 Ground Section

The enamel lamellae appear as longitudinal cracks in the enamel (some are cracks) that sometimes extend into the dentin. Unstained, 100x

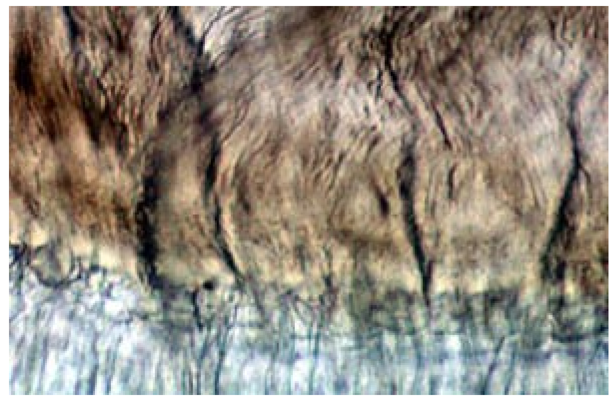


Enamel Tufts
Image 103
Ground Section



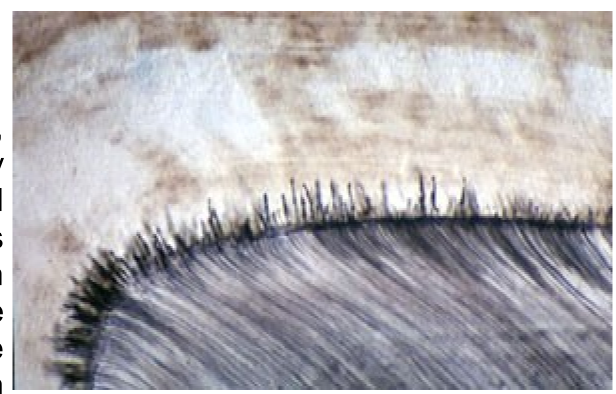
Several enamel tufts, which appear as wavy groups of enamel rods, extend from the dentinoenamel junction into enamel to about one quarter of its thickness. Unstained, 100x

Enamel Tufts
Image 104
Ground Section



Higher power of image 103. Several enamel tufts, which appear as wavy groups of enamel rods, extend from the dentinoenamel junction into enamel to about one quarter of its thickness. Unstained, 200x

Enamel Spindles
Image 105
Ground Section

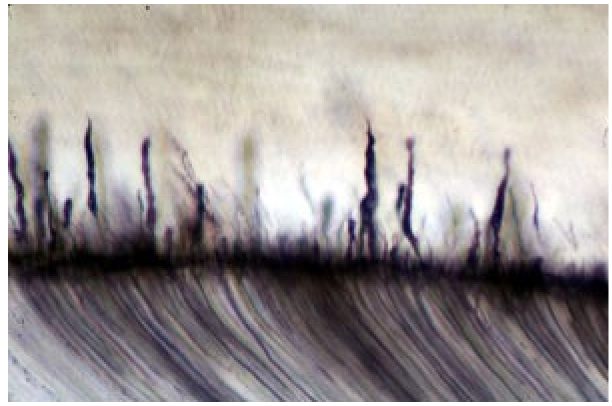


The enamel spindles appear as short, straight, thin, dark structures which extend for only short distances into enamel. They are residual tubules formed when odontoblastic processes extend across the dentinoenamel junction during odontogenesis. In ground sections, the odontoblastic processes disintegrate and are replaced by air which appears dark in transmitted light. Unstained, 100x

Enamel Spindles

Image 106

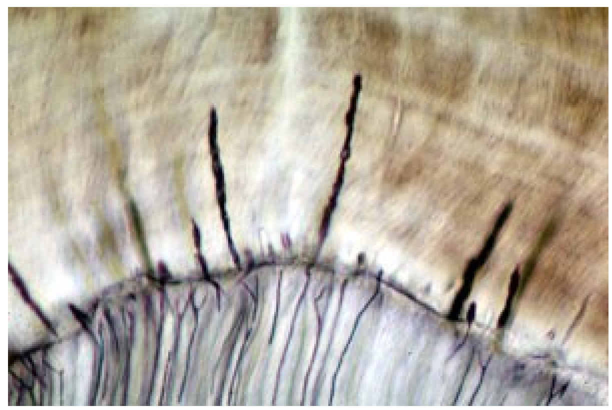
Ground Section



Higher power of image 105. The enamel spindles appear as short, straight, thin, dark structures which extend for only short distances into enamel. They are residual tubules formed when odontoblastic processes extend across the dentinoenamel junction during odontogenesis. In ground sections, the odontoblastic processes disintegrate and are replaced by air which appears dark in transmitted light. Unstained, 200x

Enamel Spindles

Image 107 Ground Section

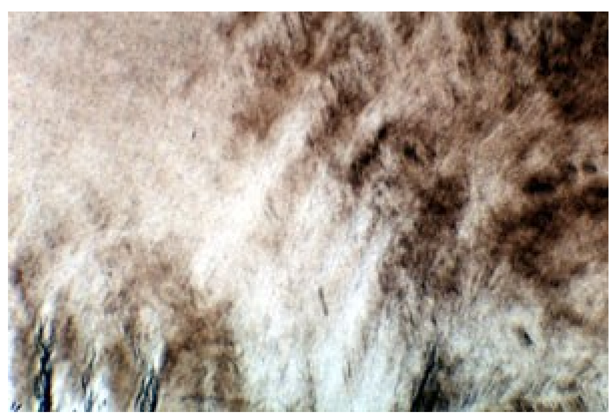


The enamel spindles appear as short, straight, thin, dark structures which extend for only short distances into enamel. They are residual tubules formed when odontoblastic processes extend across the dentinoenamel junction during odontogenesis. In ground sections, the odontoblastic processes disintegrate and are replaced by air which appears dark in transmitted light. Unstained, 200x

Gnarled Enamel

Image 108

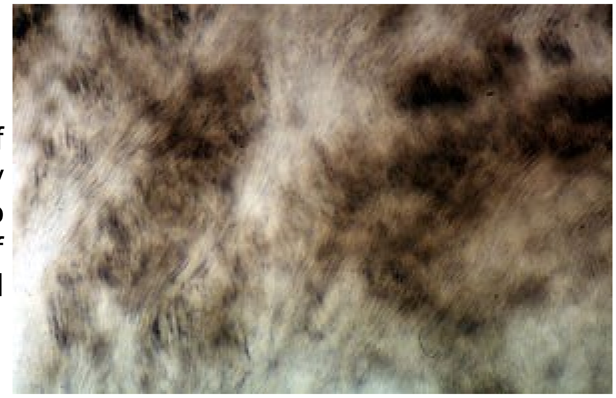
Ground Section



Bundles of enamel rods appear to intertwine in a highly irregular manner in the cusp region of teeth to form gnarled enamel. The phenomenon of gnarled enamel appears to be an optical illusion. Unstained, 40x

Gnarled Enamel

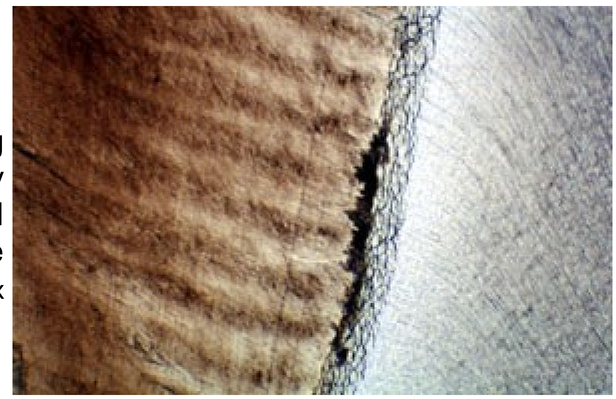
Image 109 Ground Section



Higher power of image 108. Bundles of enamel rods appear to intertwine in a highly irregular manner in the cusp region of teeth to form gnarled enamel. The phenomenon of gnarled enamel appears to be an optical illusion. Unstained, 100x

Hunter-Schreger Bands

Image 110 Ground Section



Hunter-Schreger bands appear as alternating light and dark bands in light microscopy. They are best observed in polarized or reflected light. What is the underlying basis for the appearance of this phenomenon? Unstained, 40x

Dentin

The dentin provides the bulk and general form of the tooth and is characterized as a hard tissue with tubules throughout its thickness. Since it begins to form slightly before the enamel, it determines the shape of the crown. Including the cusps and ridges, and the number and size of the roots. Along the crown, the dentin covered by enamel; along the root, by cementum. It encloses the dental pulp, with which it shares a common origin from the dental papilla. The dentin forms an interdigitating, scalloped junction with the enamel, but has a more indistinct junction with the cementum.

Physical properties

The dentin usually is light yellowish in color, becoming darker with age. It is harder than bone and cementum but softer and less brittle than enamel. Dentin has greater compressive and tensile strength than enamel. Because it is traversed by tubules, the dentin is readily permeable. The specific gravity of dentin is approximately 2.1 g/ml.

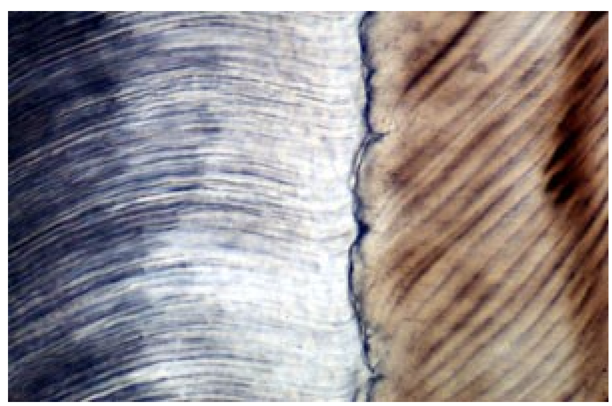
Chemical properties

Dentin is composed by weight of approximately 70% inorganic material, 20% organic material and 10% water. By volume, the same components comprise 47%, 32%, and 21% respectively. Thus, the nonmineral component is much higher than in enamel. The principal inorganic component is hydroxyapatite (present as plate-like crystallites smaller than those of enamel. Trace elements such as fluoride and carbonate are present in the crystallites. The main organic component is Type I collagen (comprising 90% of the matrix), with proteoglycans between the fibers. Other non-collagenous proteins in calcified dentin include phosphoproteins, carboxyglutamate-containing proteins, acidic glycoproteins and plasma proteins

Mantle Dentin

Image 111 Ground Section

The peripheral layer of dentin, which is the first layer of dentin deposited, is called mantle dentin. It is located adjacent to the enamel in the crowns of teeth and adjacent to the cementum in the roots. Notice the lines of Retzius in the enamel which are oriented at an angle to the dentinoenamel junction. Unstained, 100x



Primary & Secondary Dentin

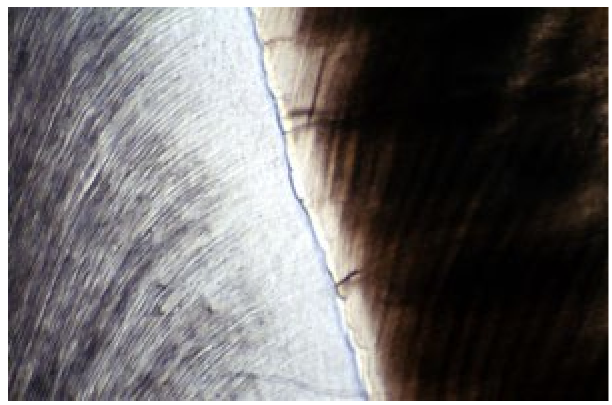
Image 112

Ground Section

The dentinal tubules scribe an S-shape pattern. Primary dentin occupies the major area of the photomicrograph. A demarcation line (located toward the left border of the frame) clearly delineates the primary dentin from the more irregular secondary dentin. A small section of enamel is visible at the right of the field. Unstained, 40x

Primary Dentin

Image 113 Ground Section



Higher power of image 112. Unstained, 100x

Primary Dentin

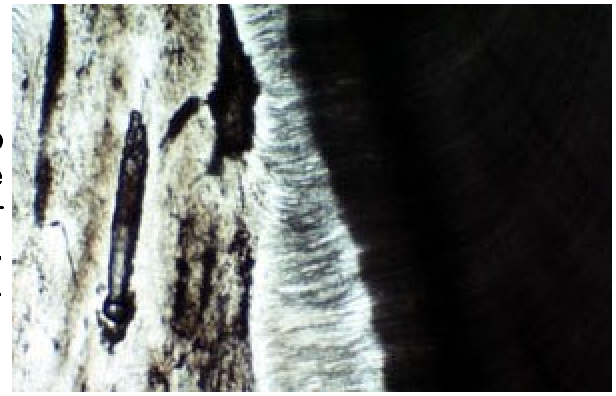
Image 114 Ground Section

Higher power of image 112. Unstained, 100x

Reparative Dentin

Image 115Ground Section

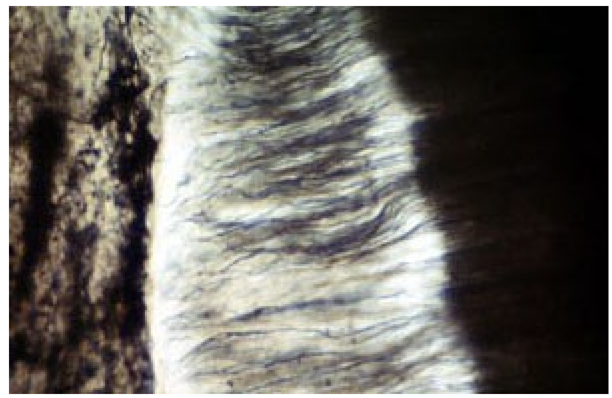
Reparative dentin is produced in response to irritation. It is a variation of dentin in which the dentinal tubules are more irregular and fewer in number than in primary or secondary dentin. The pulp is located to the left in the field. Unstained, 40x



Reparative Dentin

Image 116 Ground Section

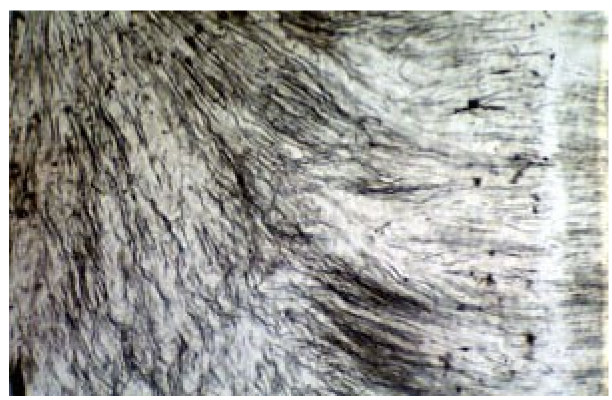
Higher power of image 115. Reparative dentin is produced in response to irritation. It is a variation of dentin in which the dentinal tubules are more irregular and fewer in number than in primary or secondary dentin. The pulp is located to the left in the field. Unstained, 100x



Reparative Dentin

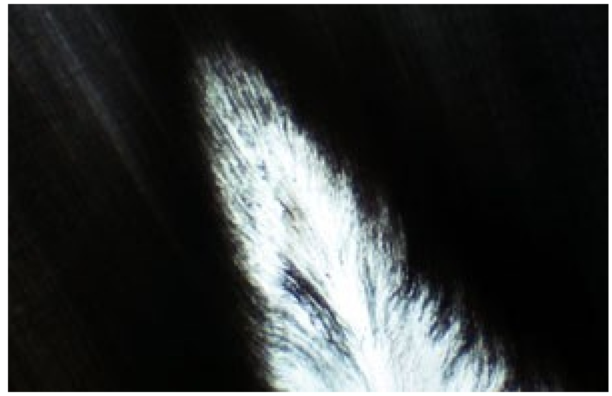
Image 117 Ground Section

Reparative (irregular) dentin. Unstained, 100x



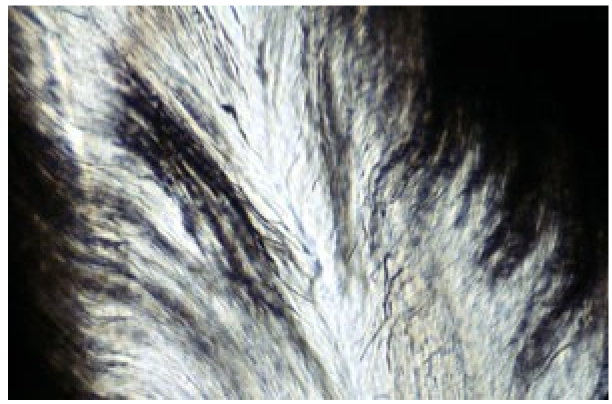
Reparative Dentin at Cusp Tip
Image 118 Ground Section

Another view of irregular dentin, this time at a cusp tip. Unstained, 40x



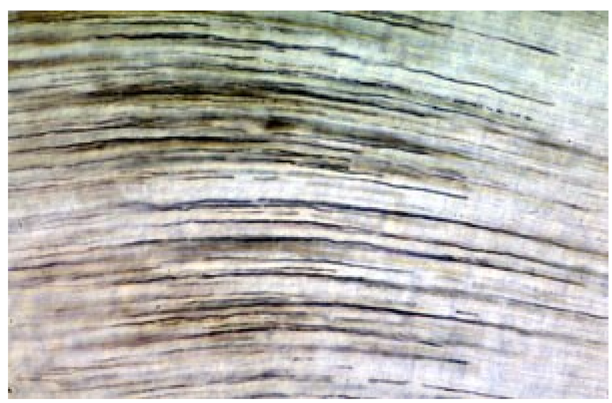
Reparative Dentin at Cusp Tip
Image 119
Sagittal Section

Higher power of image 118. Another view of irregular dentin, this time at a cusp tip. Unstained, 100x



Dentinal Tubules
Image 120
Sagittal Section

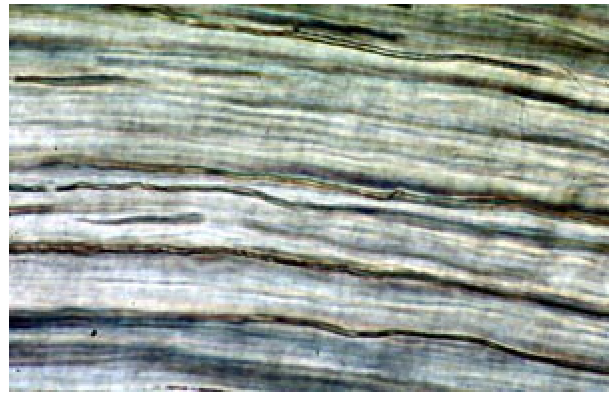
Dentinal tubules. Unstained, 100x



Dentinal Tubules

Image 121 Ground Section

Higher power of image 120. Dentinal tubules. Unstained, 400x

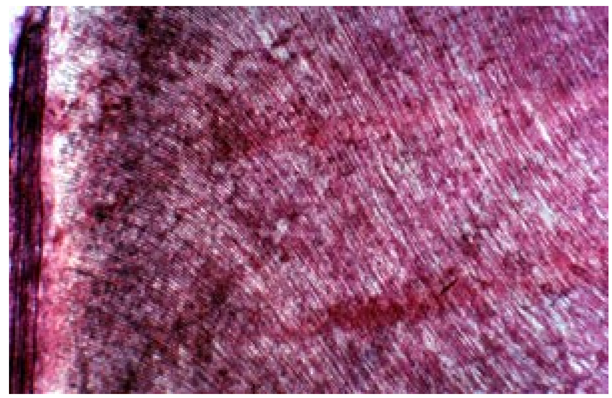


Dentin

Image 122

Decalcified Section

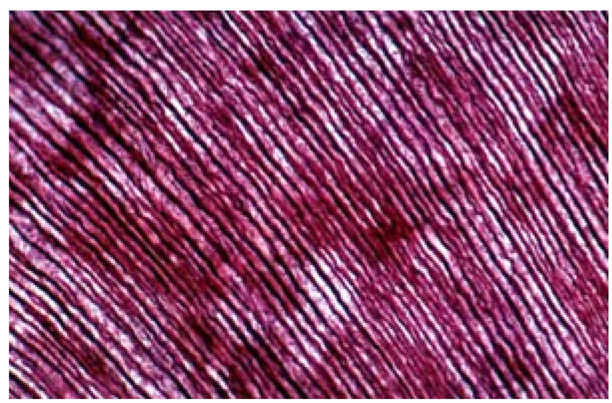
Dentin stained with a silver stain. Silver Stain, 40x



Dentin

Image 123 Decalcified Section

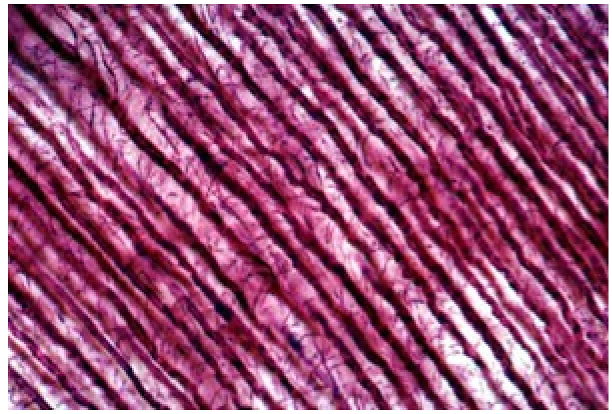
Higher power 0f image 122. The dentinal tubules have lateral canaliculi which anastomose with those from adjacent tubules. The odontoblastic processes have lateral processes which extend into the canaliculi. Silver Stain, 200x



Dentin

Image 124 Decalcified Section

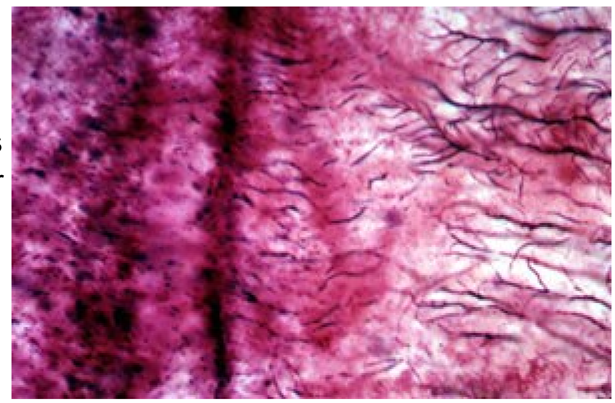
Higher power of image 123. The dentinal tubules have lateral canaliculi which anastomose with those from adjacent tubules. The odontoblastic processes have lateral processes which extend into the canaliculi. Silver Stain, 400x



Dentin & Cementum

Image 125 Decalcified Section

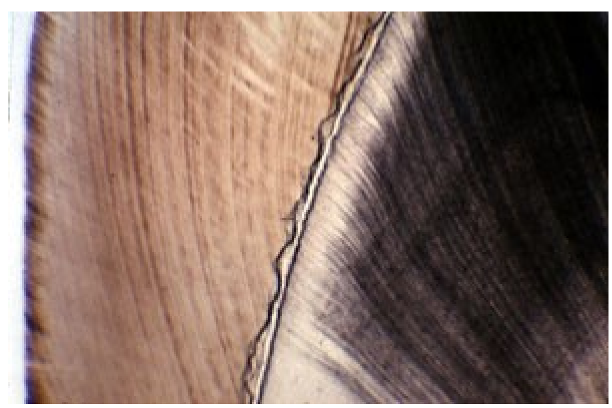
The terminal ends of the dentinal tubules branch at the dentinocementum junction. Silver Stain, 400x



Enamel & Dentin

Image 126 Decalcified Section

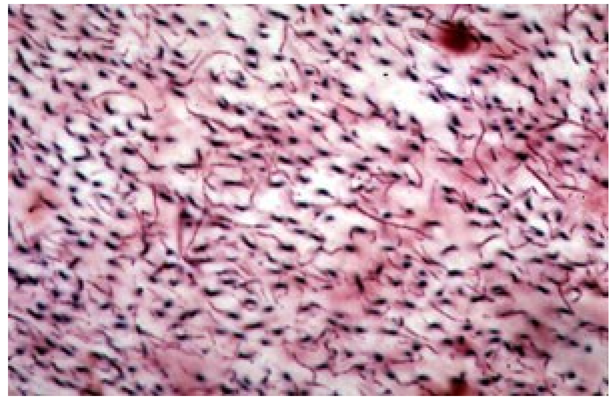
Notice the contour lines of Owen in dentin and the lines of Retzius in enamel. The two tissues are artifactitiously separated at the dentinoenamel junction. Unstained, 40x



Dentin

Image 127 Decalcified Section

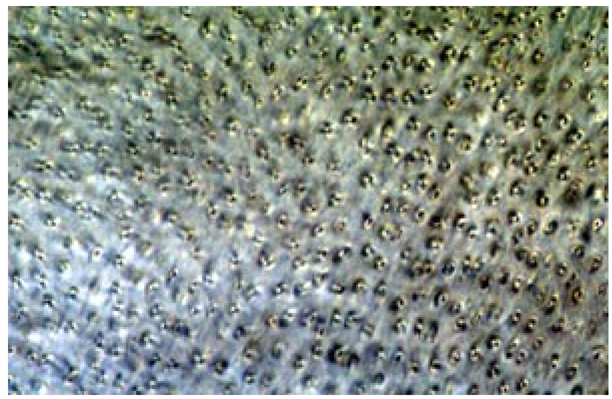
Cross section of dentinal tubules. The cut ends of the odontoblastic processes are visible. Silver Stain, 400x



Dentin

Image 128 Ground Section

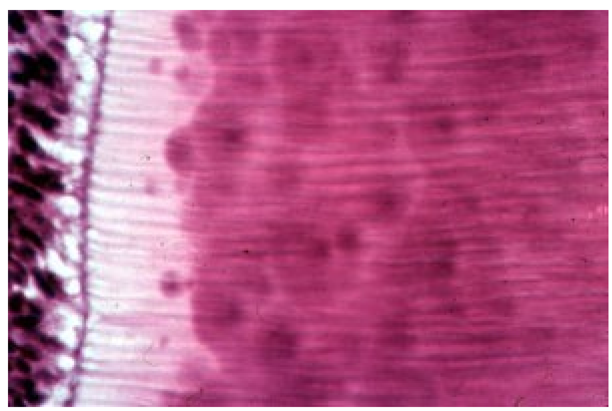
Cross section of dentinal tubules. Unstained, 400x



Dentin

Image 129 Decalcified Section

Identify dentin, predentin, odontoblasts and odontoblastic processes (Tomes' dentinal fibrillae). Silver Stain, 400x



Cementum

Cementum is the thin layer of calcified tissue covering the dentin of the root. It is one of the four tissues that support the tooth in the jaw (the periodontium). It is contiguous with the periodontal ligament on its outer surface and is firmly adherent to dentin on its deep surface. Its prime function is to give attachment to collagen fibers of the periodontal ligament. It is a specialized connective tissue that shares some physical, chemical, and structural characteristics with compact bone. Unlike bone, however, human cementum is avascular.

Physical properties

Cementum is light yellow in color and can be distinguished from enamel by its lack of luster and its darker hue. Its softer than dentin. Permeability varies with age and the type of cementum, the cellular variety being more permeable. In general, cementum is more permeable than dentin.

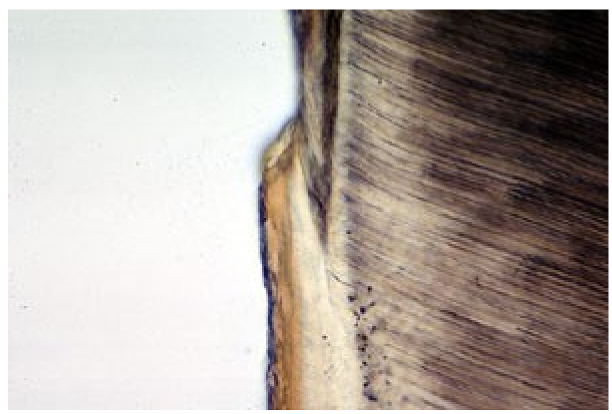
Chemical properties

On a wet weight basis, cementum contains about 45% to 50% inorganic material and 50% to 55% organic material and water. The principal inorganic component is hydroxyapatite, although other forms of calcium are present vat higher levels than in enamel and dentin. The hydroxyapatite crystals are thin and plate-like and similar to those in bone. They are on average 55 nm wide and 8nm thick. The organic matrix is primarily collagen. The collagen is virtually all Type I.

Cementoenamel Junction

Image 130 Ground Section

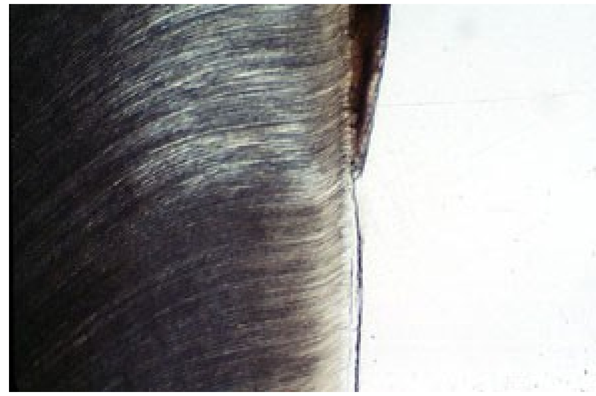
Notice that the cementum overlaps the cervical end of the enamel. This is the most common relationship between the two tissues.
Unstained, 100x



Cementoenamel Junction

Image 131 Ground Section

The cementum approximates the enamel at the cervical line. Unstained, 40x

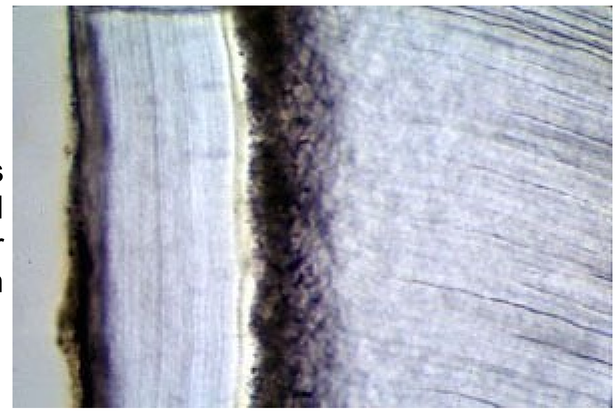


Acellular Cementum

Image 132

Ground Section

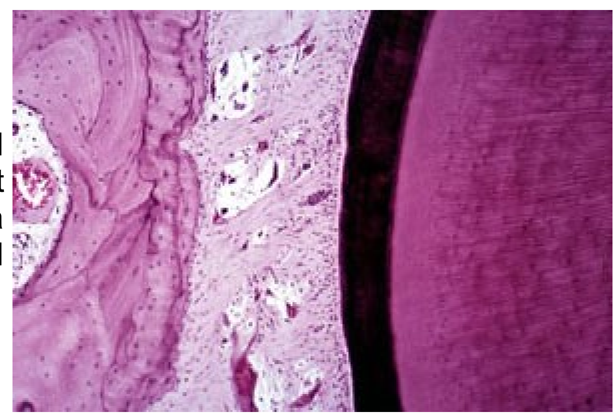
Notice that acellular cementum has incremental lines of growth which are oriented parallel to the root surface. Tomes' granular layer and dentinal tubules are also visible in the field. Unstained, 200x



Acellular Cementum

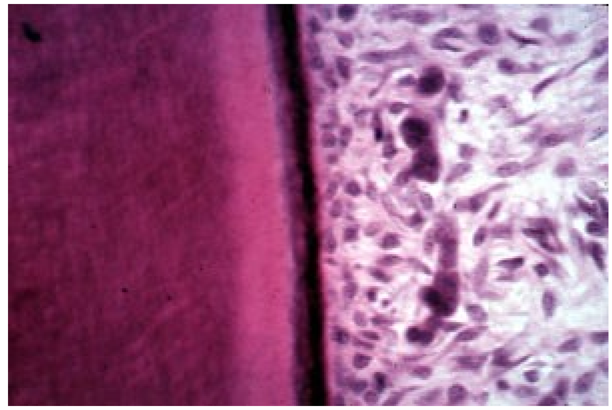
Image 133 Decalcified Section

The layer of acellular cementum is stained dark purple while the dentin is colored a light purple. The periodontal ligament and a segment of the alveolar process are located adjacent to the root. H&E, 100x



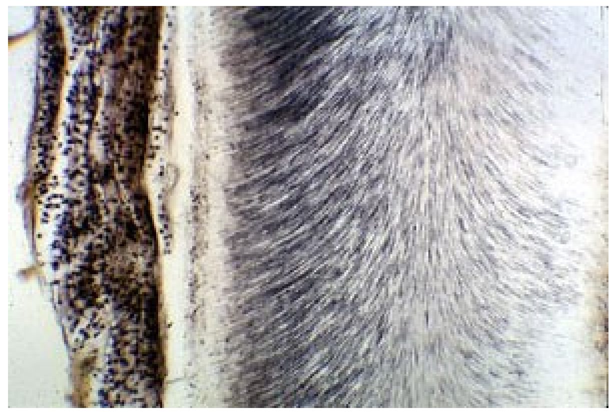
Acellular Cementum
Image 134
Decalcified Section

Higher power. H&E, 200x



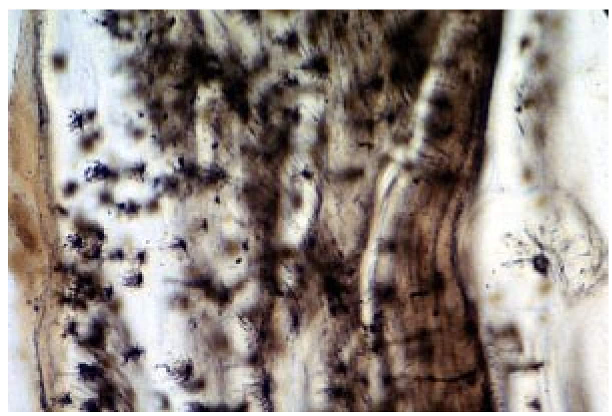
Cellular Cementum
Image 135 Ground Section

The cellular cementum is characterized by the presence of lacunae with canaliculi in which reside cementocytes. However, the cells are absent in ground section preparations. Unstained, 40x



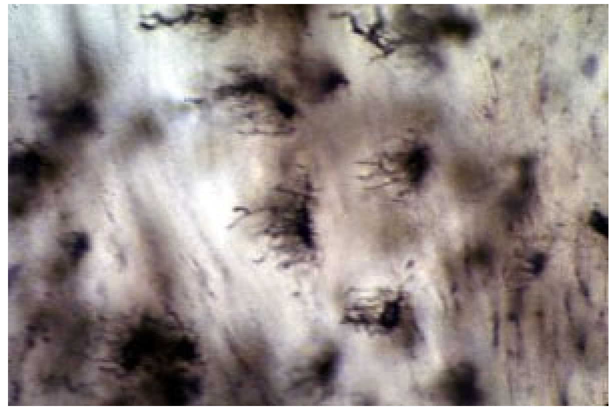
Cellular Cementum
Image 136 Ground Section

Higher magnification of image 135. Unstained, 100x



Cellular Cementum

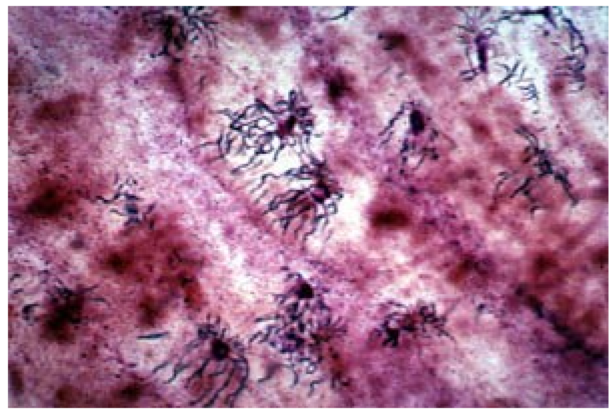
Image 137 Ground Section



Higher power of image 136. Notice that the canaliculi of cellular cementum have a tendency to be polarized and extend toward the periodontal ligament side of the root. Unstained, 400x

Cellular Cementum

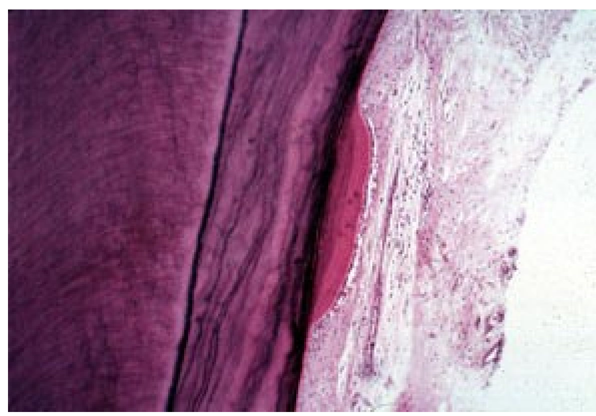
Image 138 Decalcified Section



Another view of cellular cementum. Silver Stain, 400x

Hypercementosis

Image 139 Decalcified Section

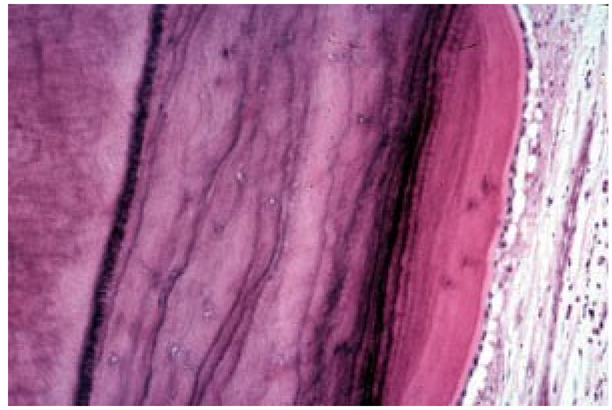


A localized hyperdeposition of cementum termed hypercementosis is attached to a layer of cellular cementum. H&E, 40x

Hypercementosis

Image 140 Decalcified Section

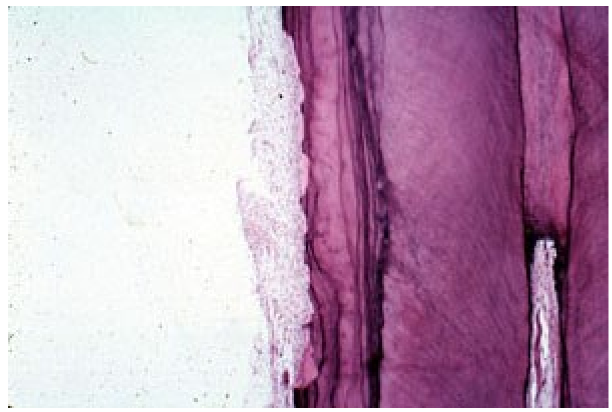
Higher power of image 139. Identify the structural features of cementum which you have studied in previous images. H&E, 100x



Cementum Resorption & Repair

Image 141 Decalcified Section

The resorbed surface of the cementum has a scalloped appearance. Areas of newly deposited cementum as well as numerous incremental lines of growth are visible. H&E, 40x



Dental Pulp

The dental pulp is the loose connective tissue which occupies the pulp chamber in the centre of the tooth. It is the mature form of the dental papilla. The morphology of the chamber varies from tooth to tooth. In the crowns (coronal pulp) of molar teeth the pulp extends under the cusps into pulp horns. It is present in each root canal (radicular pulp). At the apical constriction of the root canal the pulp becomes continuous with the periodontal ligament. Smaller accessory canals pass laterally through the root dentin to reach the periodontal ligament.

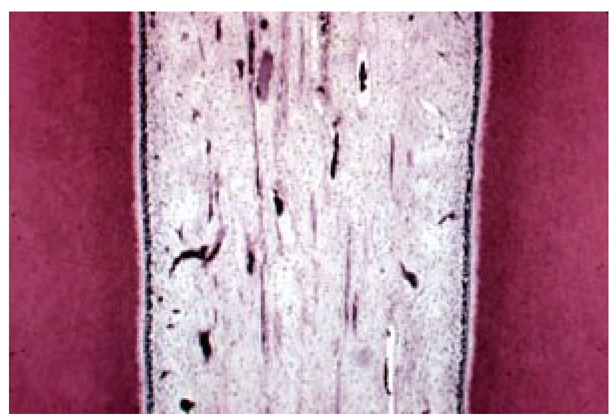
The dental pulp has many features in common with other soft connective tissue, consisting of cells (principally fibroblasts) embedded in an extracellular matrix of fibers (mainly collagen) and ground substance. The tissue has an extensive nerve and vascular supply. By weight, the pulp is 75% water and 25% organic material. The dental pulp acts as a sensory organ, but usually only when the dentin is exposed

The major function of the pulp are fulfilled by a layer of dentin-forming cells (the odontoblasts) located at the periphery of the tissue. The odontoblasts form a clearly defined layer in contact with the dentin. This layer is thicker in the crown than in the root of the tooth. Beneath the odontoblast layer, there is often (but not always) an apparently cell-free zone (of Weil) which contains a plexus of nerves and capillaries. Deep to this is a region of increased cell density (the cell-rich zone). The cell-rich zone gradually blends with the central bulk of the pulp which, apart from containing nerves and vessels, is a sparse mixture of cells and fibers. The cell-free zone is usually absent in radicular pulp.

Dental Pulp

Image 142 Decalcified Section

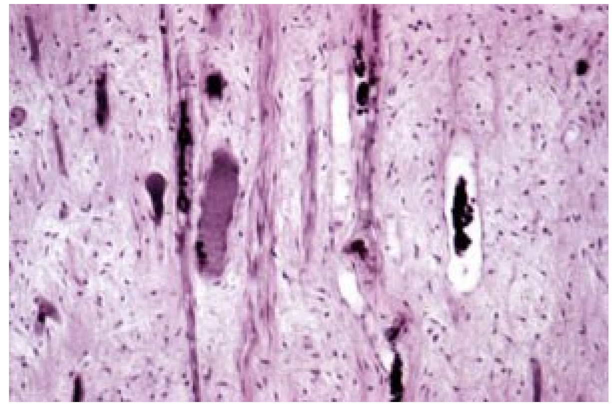
The dental pulp is enclosed by the dentin walls of the root. Longitudinal section. H&E, 40x



Dental Pulp

Image 143 Ground Section

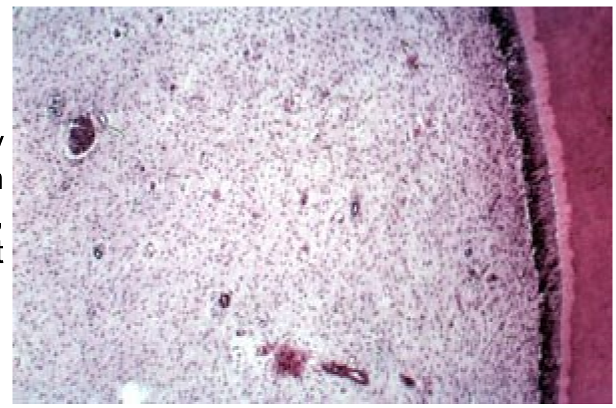
Higher power of image 142. The dental pulp is a specialized variety of connective tissue. Its structural composition varies with age. Numerous neurovascular bundles are visible. H&E, 100x



Dental Pulp

Image 144 Decalcified Section

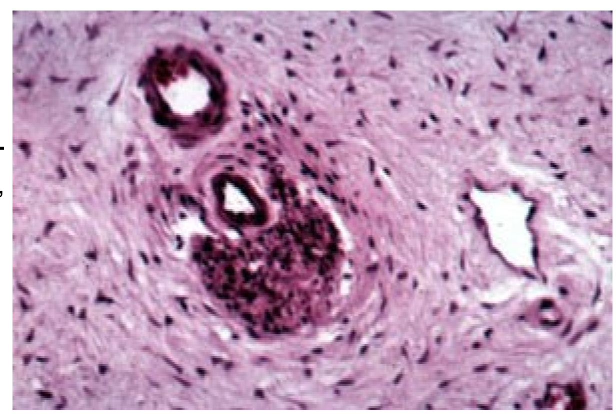
The dental pulp in this specimen is highly cellular. Neurovascular bundles appear in cross-section. A layer of tall odontoblasts, predentin and dentin are located at the right border of the photomicrograph. H&E, 40x



Dental Pulp

Image 145 Decalcified Section

Higher power of image 144. A pulpal neuro-vascular bundle is seen in cross section. H&E, 200x

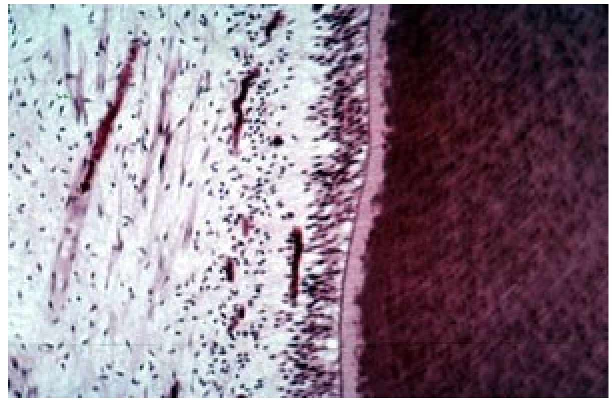


Dental Pulp & Dentin

Image 146

Decalcified Section

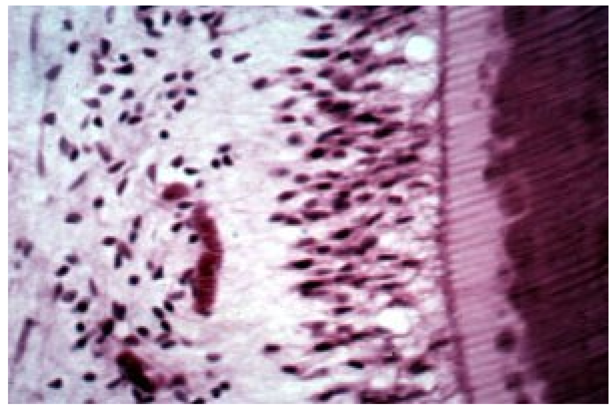
Higher power of image 142. Scanning from left.to right, identify the pulp core, cell-rich zone, cell-free zone of Weil, odontoblast layer, predentin and dentin. H&E, 100x



Dental Pulp & Dentin

Image 147 Decalcified Section

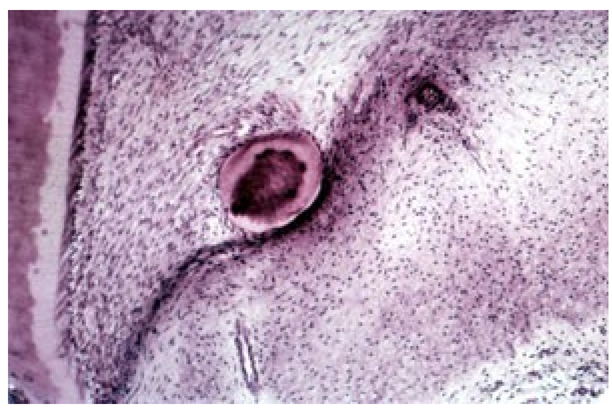
Higher power of image 146. Scanning from left.to right, identify the cell-rich zone, cell-free zone of Weil, odontoblast layer, predentin and dentin. H&E, 400x



Free True Denticle

Image 148 Decalcified Section

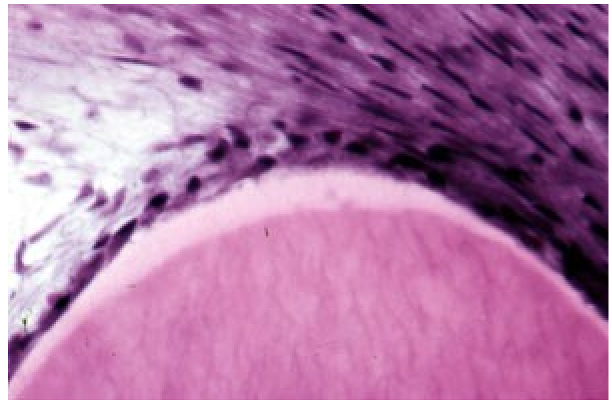
A true denticle is located at the wide apical foramen of a developing root. H&E, 100x



Free True Denticle

Image 149 Decalcified Section

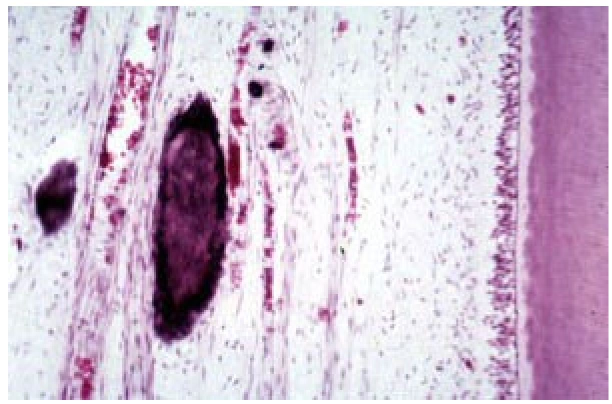
Higher power of image 148. Notice the irregular dentinal tubules which are located within the true denticle. H&E, 400x



False Denticle

Image 150 Decalcified Section

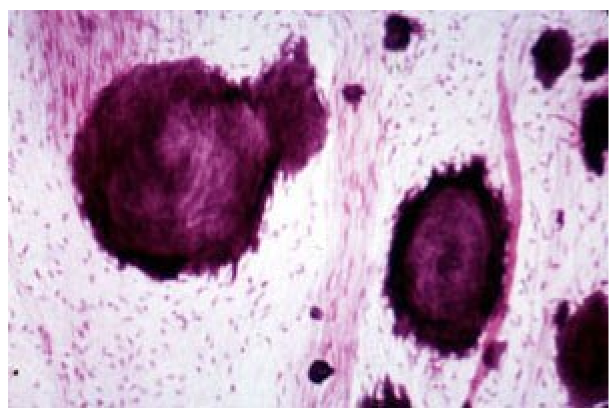
Higher power of image 142. The false denticle has an amorphous appearance. It is a mineralized body but is not dentin. H&E, 100x



Free False Denticle

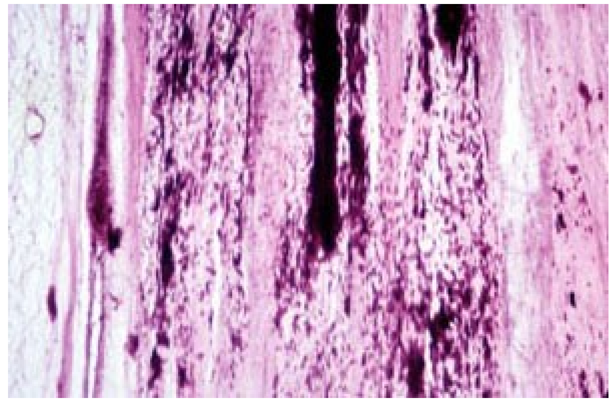
Image 151 Decalcified Section

Another free false denticle. H&E, 100x



Diffuse Pulp Calcification

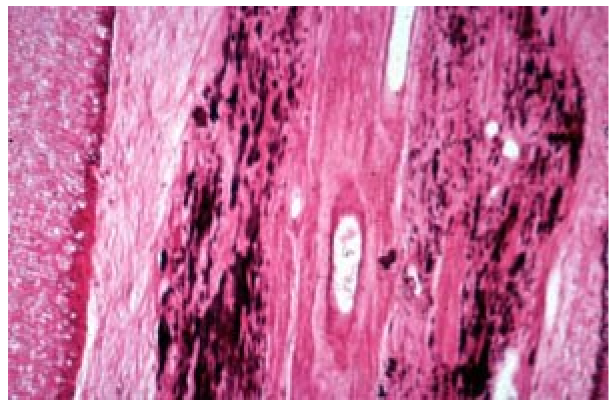
Image 152 Decalcified Section



Small amorphous mineralizations occur in close association with pulpal blood vessels. H&E, 100x

Diffuse Pulp Calcification

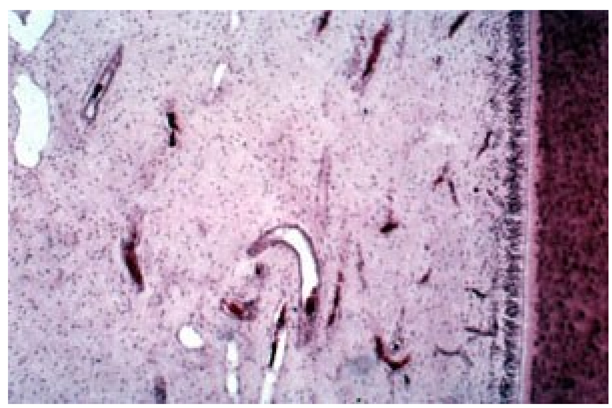
Image 153 Decalcified Section



Notice that the pulp tissue proper is highly fibrous. Both the calcifications and fibrosis are signs of regression or pulpal aging. H&E, 100x

Dental Pulp & Dentin

Image 154 Decalcified Section

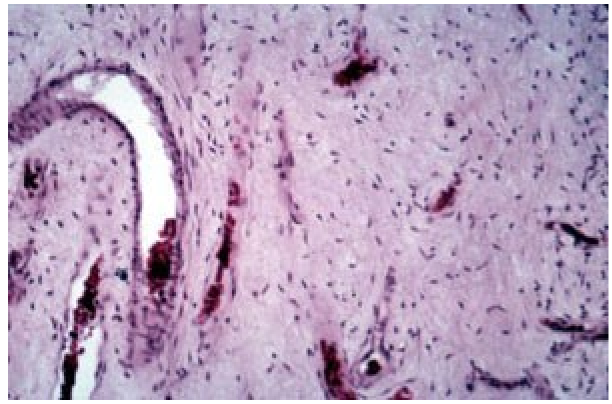


Another view of dental pulp. H&E, 40x

Dental Pulp

Image 155 Ground Section

Higher power of image 154. Dental pulp core with neurovascular bundles. H&E, 100x



Periodontal ligament

The periodontal ligament occupies the periodontal space, which is located between the cementum and the periodontal surface of the alveolar bone, and extend coronally to the most apical part of the lamina propria of the gingiva. Collagen fibers of the periodontal ligament are embedded in cementum and alveolar bone so that the ligament provides soft-tissue continuity between the mineralized connective tissues of the periodontium.

The periodontal ligament is a fibrous connective tissue that is noticeably cellular and contains numerous blood vessels. All connective tissues, the periodontal ligament included, comprise cells as well as extracellular matrix consisting of fibers and ground substance. The majority of the fibers of the periodontal ligament are collagen, and the matrix is composed of a variety of macromolecules, the basic constituents of which are proteins and polysaccharides.

The periodontal ligament has the following functions:

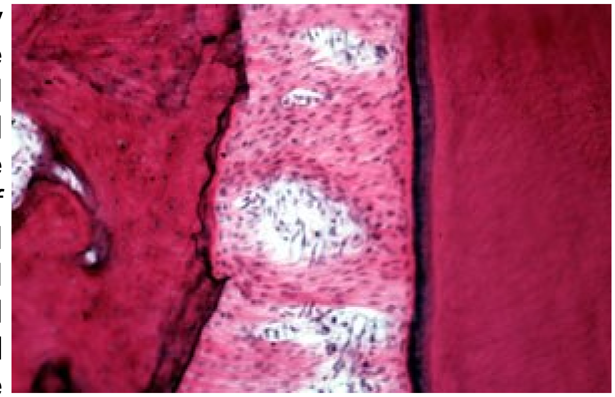
1. It is the tissue of attachment between the tooth and alveolar bone. It is thus responsible for resisting displacing forces and it protect the dental tissues from damage caused by excessive occlusal loads.
2. It is responsible for the mechanism whereby a tooth attains, and then maintains, its functional position. This includes the mechanism of tooth eruption, tooth support, and drift.
3. Its mechanoreceptors are involved in the neurological control of mastication.

The collagen fibers in periodontal ligament are found to be gathered into bundles having clear orientation relative to the periodontal space, and these are termed principal fibers. The principal fibers are arranged in five particular groups, each group having a name, as follows:

1- Alveolar crest group. The fiber bundles of this group radiated from the crest of the alveolar process and attach themselves to the cervical part of the cementum.
2- Horizontal group. The bundles run at right angles to the long axis of the tooth from the cementum to the bone.
3- Oblique group. The bundles run obliquely. They are attached in the cementum somewhat apically from their attachment to the bone. These fiber bundles are most numerous and constitute the main attachment of the tooth.
4- Apical group. The bundles are irregularly arranged and radiate from the apical region of the root to the surrounding bone.
5- Interradicular group. From the crest of the interradicular septum, bundles extend to the furcation of multirooted teeth.

Horizontal Fibers

Image 156 Decalcified Section

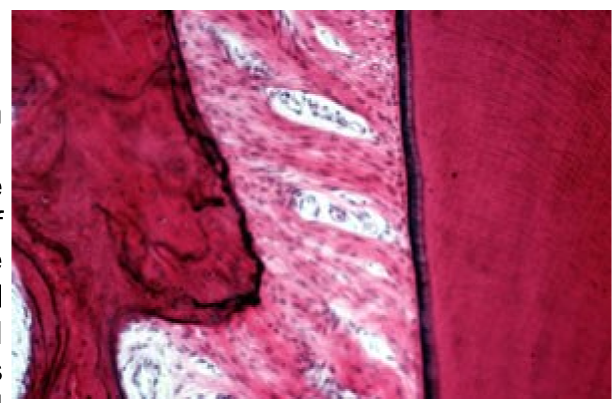


The horizontal fibers follow a wavy course (as do the other groups of principal fibers) as they pass from tooth to alveolar bone and therefore individual collagen fibers cannot be traced across the entire width of the periodontal ligament space. Notice that a section of the alveolar bone surface shows signs of remodeling. The layer of cementum (stained blue) is lined by a layer of cementoid (stained pink). Interstitial areas which contain blood vessels, nerves and supporting interstitial fibers are interposed between the dense bundles of periodontal ligament principal fibers. Most of the cells of the periodontal ligament are fibroblasts which are generally oriented parallel to the principal fibers. H&E, 40x

Oblique Fibers

Image 157

Decalcified Section

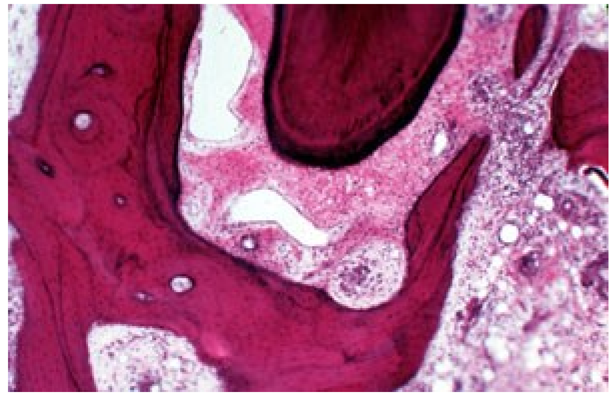


The oblique fibers extend from the cementum to the alveolar bone in a coronal direction. Interstitial areas of loose fibrous connective tissue are found between the groups of principal fibers. The alignment of the oblique fibers purportedly resists the apical displacement of the tooth by vertically applied masticatory forces. The oblique fibers constitute the largest group of periodontal ligament principal fibers. H&E, 40x

Apical Fibers

Image 158 Decalcified Section

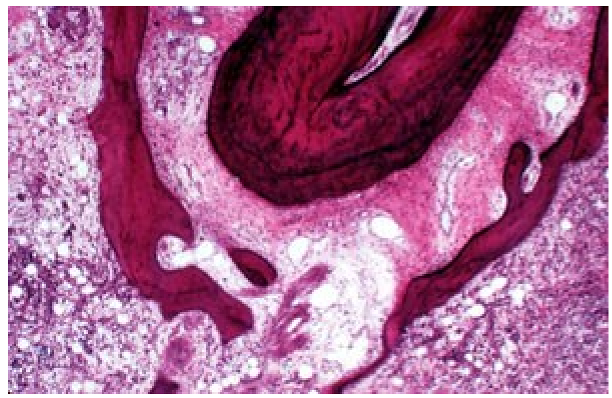
The apical fibers radiate from the apex of the tooth to the surrounding alveolar bone. Apical fibers are commonly not directionally aligned. Several large vascular channels are located in the periodontal ligament. H&E, 40x



Apical Fibers

Image 159 Decalcified Section

The apical fiber group depicted in this image is sparse. The apical alveolar bone is comprised of thin bone spicules and displays a relatively large amount of bone marrow. A short section of the pulp canal is visible within the tooth root. H&E, 40x



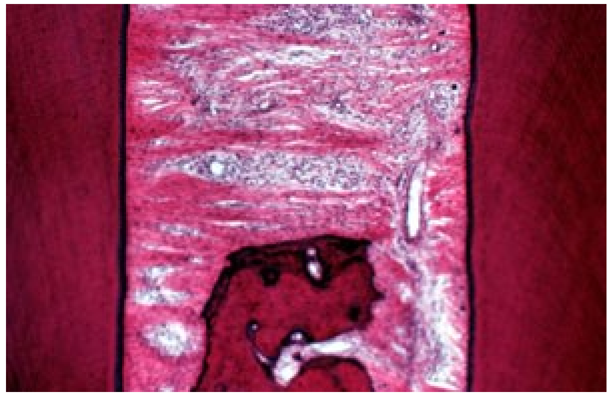
Interradicular Fibers

Image 160 Decalcified Section

In this image interradicular fibers occur in the bifurcation of a mandibular molar tooth. They pass from the cementum to the crest of the interradicular septum. Loss of the periodontal ligament and bone in this region of the tooth results in a pathological entity known as a furcation involvement. H&E, 40x

Transseptal Fibers

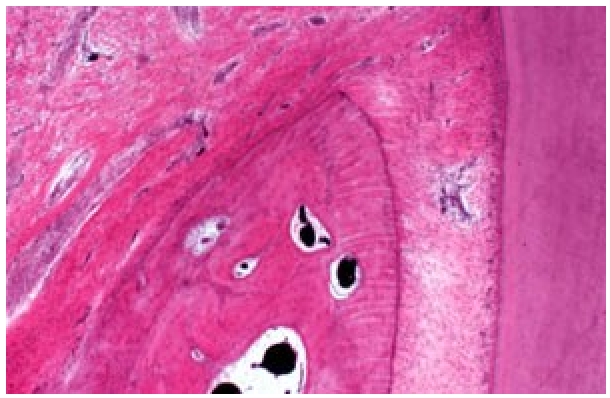
Image 161
Decalcified Section



The transseptal fibers extend from one tooth to an adjacent tooth over the crest of the interdental septum. In the intact dentition they collectively form a biological splint. The fibers blend into the periosteum at the crest of the bony septum. Transseptal fibers always exist in healthy states even after a history of crestal bone loss during inflammatory periodontal disease. H&E, 40x

Alveolar Crest Fibers

Image 162 Decalcified Section

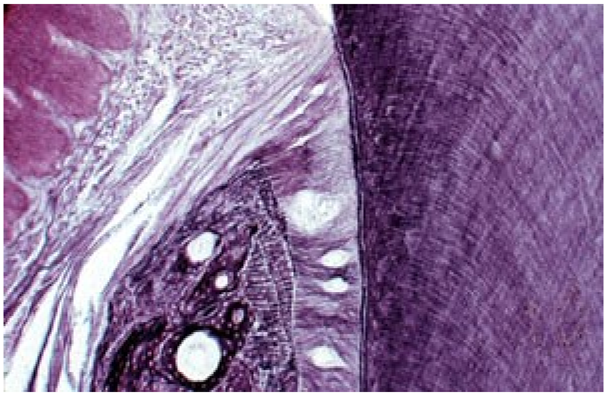


The alveolar crest fibers are the most coronal of the dentoalveolar group of periodontal ligament fibers. They run in an apical direction from tooth cementum to the alveolar crest. The cementum layer is very thin and is difficult to resolve at the power of this image. Sharpey's fibers which are embedded in the alveolar bone proper appear as deeply stained pink linear structures. The horizontal group of principal fibers is apical to the alveolar crest fiber group. H&E, 40x

Alveolar Crest Fibers

Image 163 Decalcified Section

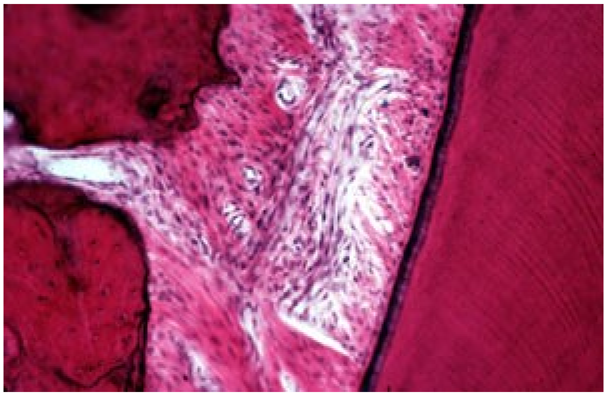
Note that the principal fibers of the periodontal ligament extend into the bundle bone of the alveolar process as so-called Sharpey's fibers. Silver Stain, 40x



Interstitial Area

Image 164 Decalcified Section

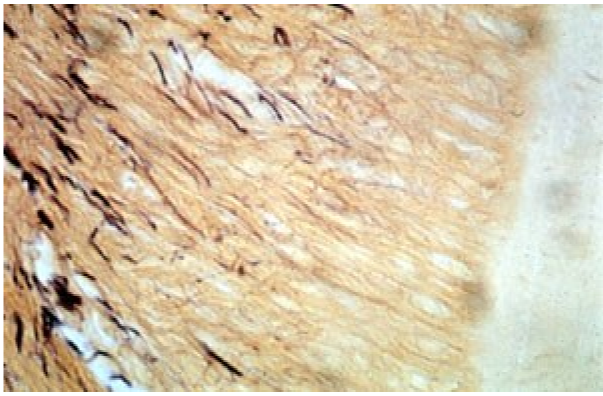
In addition to the constituents of the interstitial areas, observe the Volkmann's canal of the alveolar bone and the epithelial rests of the periodontal ligament. H&E, 100x



Oxytalan Fibers

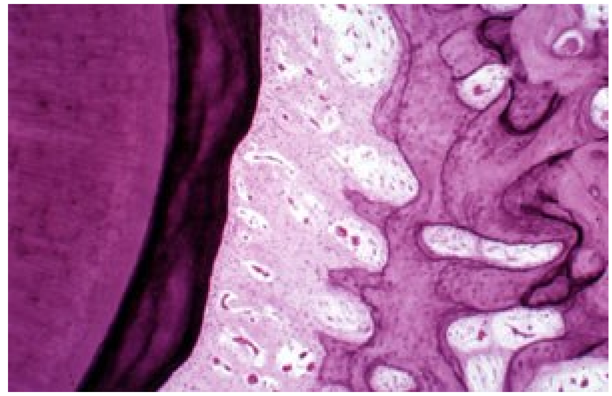
Image 165 Decalcified Section

The oxytalan fibers are stained a deep violet color in this specimen. Oxytalan fibers are related to elastic fibers and appear in larger numbers when the periodontal ligament is subjected to increased stress. Peracetic Acid-Aldehyde Fuchsin, 400x



Peridontal Ligament

Image 166 Transverse Section

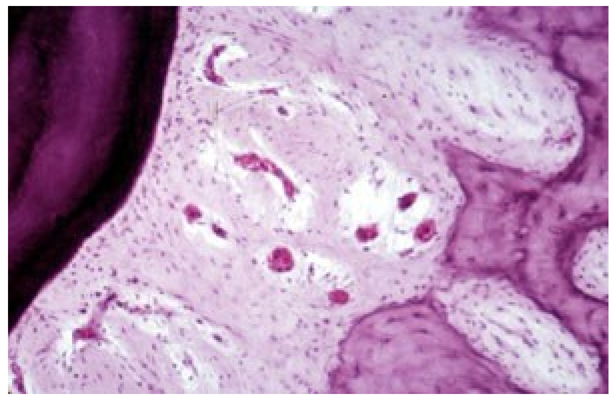


Observe the bundles of principal Fibers, interstitial areas, cementum and alveolar bone. H&E, 40x

Periodontal Ligament

Image 167

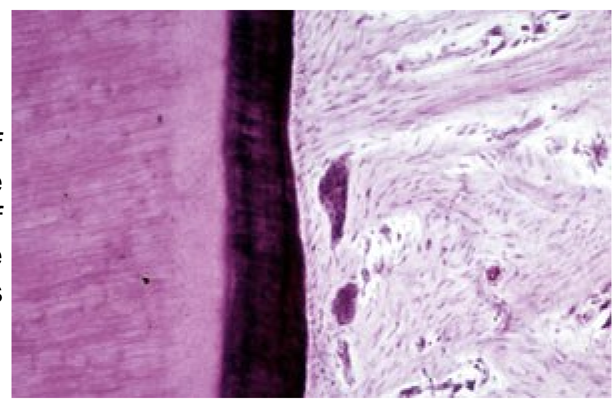
Transverse Section



Higher power of image 166. Note the vascular interstitial areas present within the periodontal ligament. H&E, 100x

Epithelial Rests of Malassez

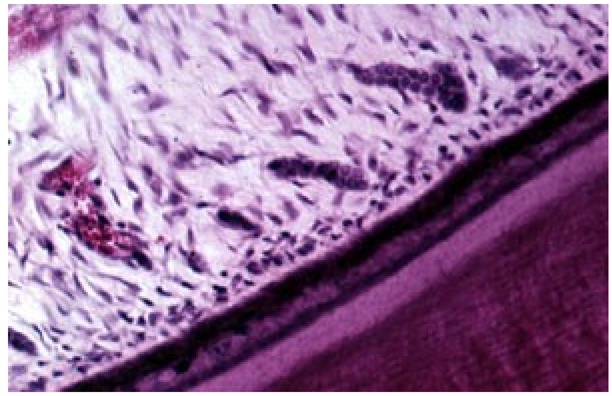
Image 168 Decalcified Section



The epithelial rests appear as small clusters of epithelial cells which are located in the periodontal ligament adjacent to the surface of cementum. They are cellular residues of the embryonic structure known as Hertwig's epithelial root sheath. H&E, 100x

Epithelial Rests of Malassez

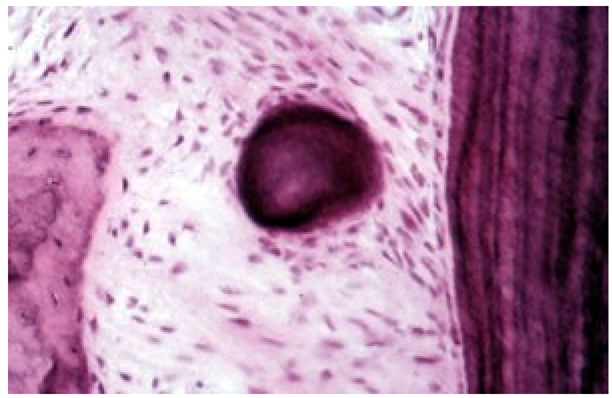
Image 169 Decalcified Section



Observe the epithelial rests, cementoblasts and the layer of acellular cementum. Although the normal function of epithelial rests is unknown, they can develop into pathological dental cysts. H&E, 200x

Free Cementicle

Image 170 Decalcified Section



Higher power. H&E, 200x

Alveolar bone (Process)

That part of the maxilla or mandible which supports and protects the teeth is known as alveolar bone (process). An arbitrary boundary at the level of the root apices of the teeth separates the alveolar processes from the body of the mandible or the maxilla. Among its other functions, alveolar bone gives attachment to muscles, provides a framework for bone marrow, and acts as reservoir for ion (especially calcium). Alveolar bone is dependent on the presence of teeth for its development and maintenance. Where teeth are congenitally absent (as in anodontia), alveolar bone is poorly developed. Following tooth extraction, it atrophies.

Bone is a mineralized connective tissue. About 60% of its wet weight is inorganic material, about 25% organic material and about 15% water. By volume, about 36% is inorganic, 36% is organic and 28% is water. The mineral phase is hydroxyapatite, in the form of needle-like crystallites or thin plates about 8nm thick and of variable length. About 90% of the organic material is present as Type I collagen. In addition, there are small amounts of other proteins (e.g. osteocalin, osteonectin, osteopontin and proteoglycans) whose biological functions remain largely unknown.

Macroscopically, bone can be classified as compact (cortical) or spongy (cancellous). As the name suggest, compact bone forms a dense, solid mass, while in spongy bone there is a lattice arrangement of the individual bone trabeculae which surround soft tissue.

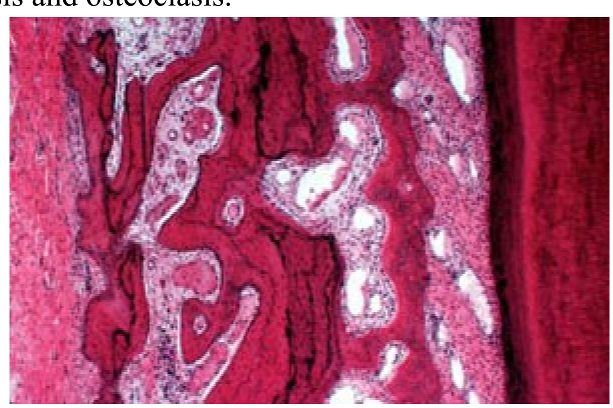
Cell types in bone

Five cell types can be distinguished in bone. The bone-forming cells are termed osteoblasts and are found on the surface. They become trapped in their own secretion and subsequently become incorporated into the matrix as osteocytes. Large multinucleated cells are responsible for resorbing bone and are called osteoclasts. In addition to these three principal cell types, osteoprogenitor and bone-lining cells can be identified. Osteoprogenitor cells are mesenchymal, fibroblast-like cells, regarded as forming a stem cell population to generate osteoblasts. They are situated in the vicinity of the blood vessels of the periodontal ligament. When alveolar bone is not being deposited or resorbed (which is probably the case throughout a considerable part of adult life), its quiescent surface is lined by relatively undifferentiated, flattened cells termed bone-lining cells. They may represent inactive osteoblasts, but little is known about them. By providing a lining to the bone surface, they may have important functions, perhaps related to ion exchange and the process of osteoblasis and osteoclasis.

Alveolar Process

Image 171 Decalcified Section

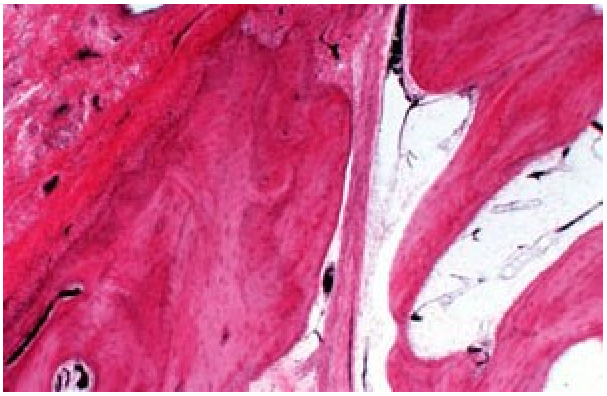
Scanning from left to right, identify the cortical plate (relatively thin), spongiosa, alveolar bone proper, periodontal ligament and the tooth root. H&E, 40x



Alveolar Process

Image 172
Decalcified Section

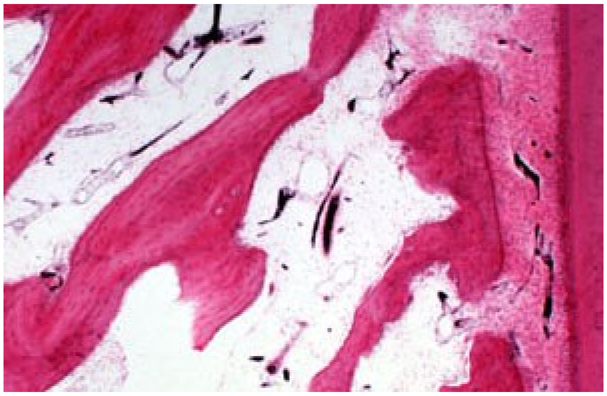
A thick cortical plate composed of compact bone is located at the left side of the field and the spongiosa is located at the right side. H&E, 40x



Cribriform Plate

Image 173 Decalcified Section

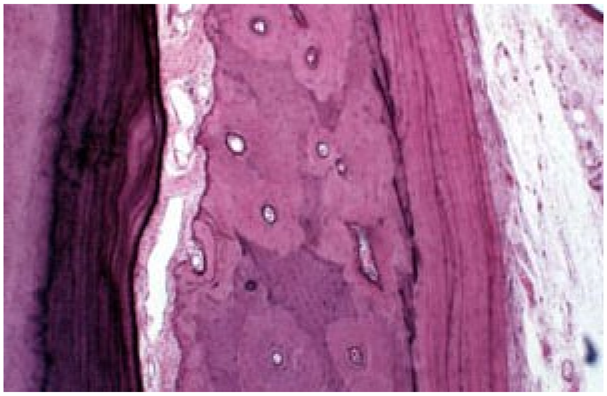
Photomicrograph of an area "toothward" to the previous image. The cancellous bone of the alveolar process occupies the major portion of the field. The periodontal ligament is lined by the cribriform plate (alveolar bone proper) which is perforated at two places by Volkmann's canals. H&E, 40x



Alveolar Process

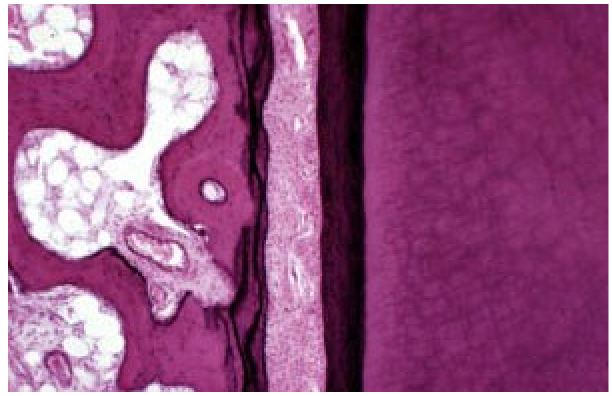
Image 174 Decalcified Section

In this specimen, no spongiosa is present between the cortical plate and the alveolar bone proper at the alveolar crest region. Parallel lamellae of bone are evident in the outer cortical plate while Haversian systems are found in the inner cortical region. H&E, 40x



Bundle Bone

Image 175 Decalcified Section

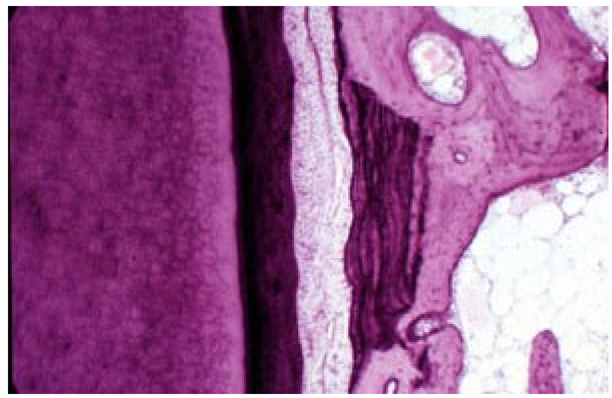


The darker stained area of the alveolar bone proper is a region of bundle bone. Bundle bone is found particularly in areas of recent bone apposition. Lines of rest are visible within the bundle bone. Identify other structural features which occur in this photomicrograph. H&E, 40x

Bundle Bone

Image 176

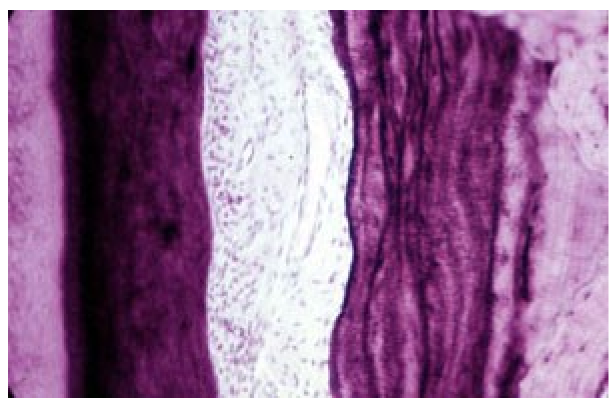
Decalcified Section



Identify the small area of deeply stained bundle bone and more lightly stained lamellar bone which are the two varieties of bone tissue found in the alveolar bone proper. H&E, 40x

Bundle Bone

Image 177 Decalcified Section

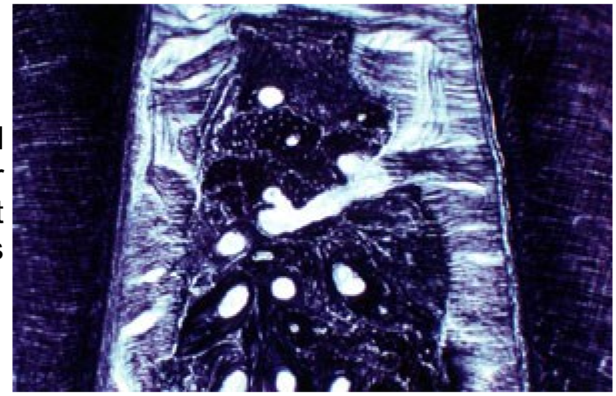


Higher power of image 176. H&E, 100x

Interdental Septum

Image 178 Decalcified Section

In this mesiodistal section an interdental septum and associated periodontal fiber groups are visible. The roots of the adjacent teeth are located at the left and right borders of the field. Silver Stain, 40x



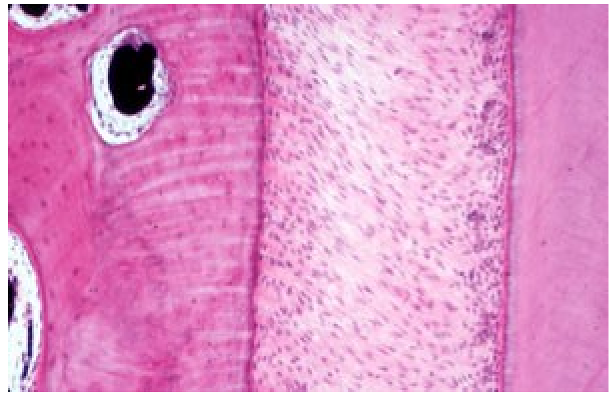
Sharpey's fibers

In addition to intrinsic fibers secreted by osteoblasts, alveolar bone also contains extrinsic fibers. Extrinsic fibers, inserting into the cribriform plate as Sharpey's fibers, are derived from the principal fibers of the periodontal ligament. Most Sharpey's fibers appear in the cervical portion (alveolar crest region) of the cribriform plate.

Sharpey's Fibers

Image 179 Decalcified Section

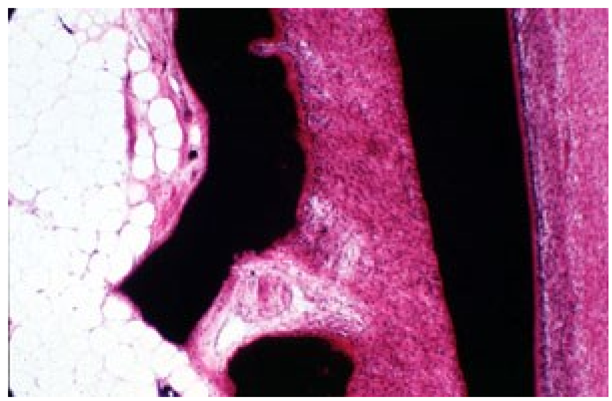
Sharpey's fibers appear as dark pink streaks within the bundle bone of the alveolar process. Identify other structures in this image. H&E, 100x



Alveolar Bone Proper

Image 180 Decalcified Section

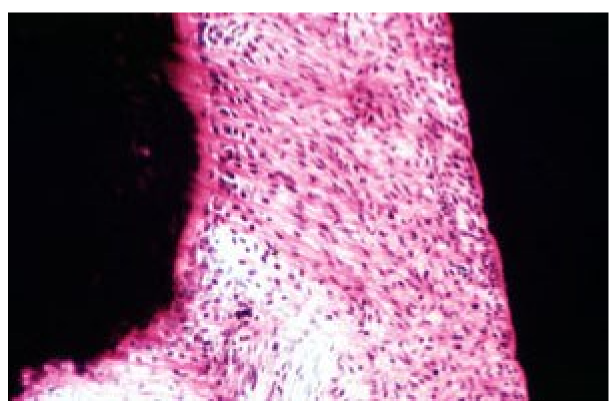
Mineralized bone and dentin are stained black. The periodontal ligament is located in the center of the field. Note the communicating Volkmann's canal located between the fatty marrow of the alveolus and the periodontal ligament. Silver Stain, 40x



Alveolar Bone Proper

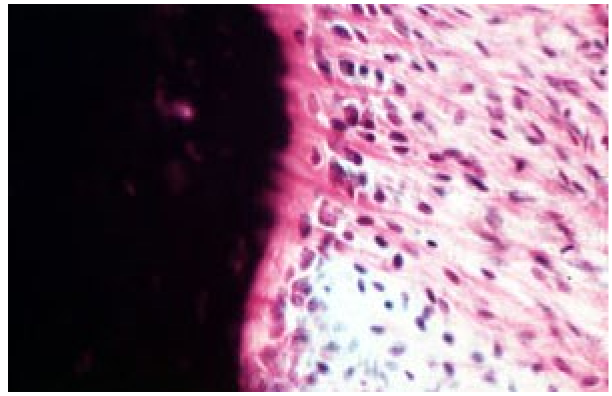
Image 181 Decalcified Section

Higher power of the previous image. Oblique fibers are traversing osteoid and mineralized bone and traversing cementoid and cementum. Identify fibroblasts, osteoblasts and cementoblasts. Silver Stain, 100x



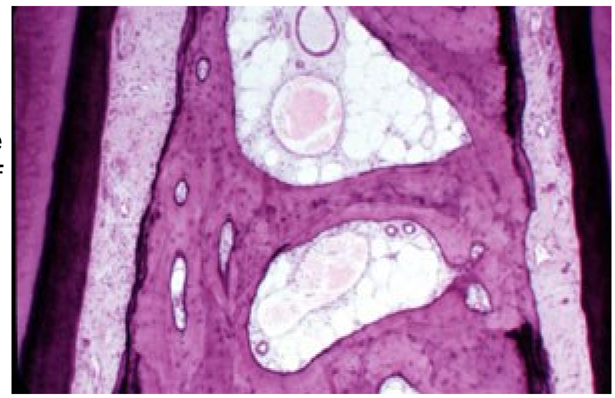
Alveolar Bone Proper
Image 182 Decalcified Section

Higher power of image 181. Oblique fibers are traversing osteoid and mineralized bone and traversing cementoid and cementum. Identify fibroblasts, osteoblasts and cementoblasts. Silver Stain, 200x



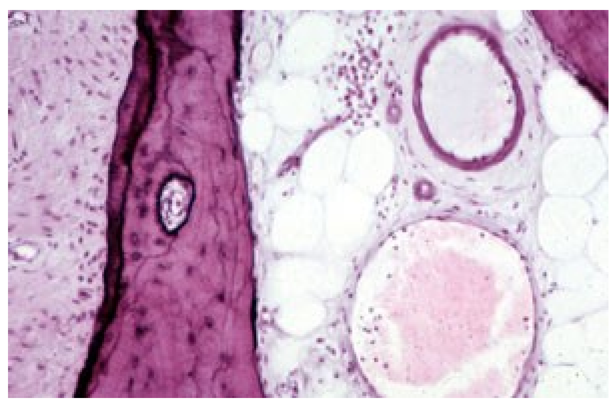
Interradicular Septum
Image 183 Decalcified Section

Observe the large marrow spaces of the septum and the deeply stained layers of bundle bone. H&E, 40x



Interradicular Septum
Image 184 Decalcified Section

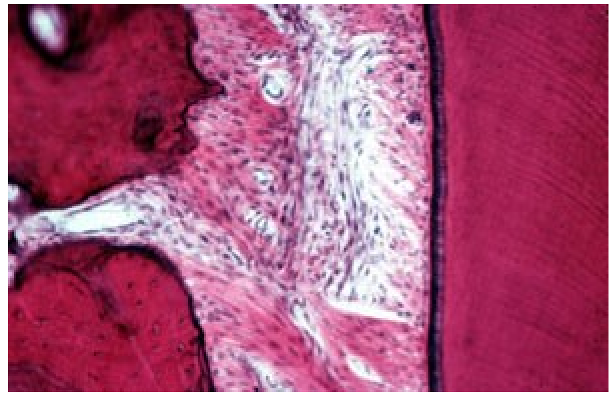
Higher power of image 183. H&E, 100x



Periodontium

Image 185 Longitudinal Section

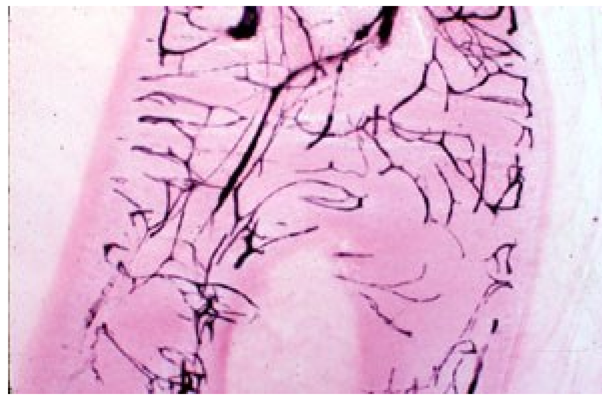
Identify the various structures of the periodontium. H&E, 100x



PDL Vasculature

Image 186 Decalcified Section

A cleared carbon-gelatin-injected jaw specimen. A plexus of vessels from adjacent periodontal ligaments and an interdental papilla are displayed. Cleared Carbon Injection, 100x



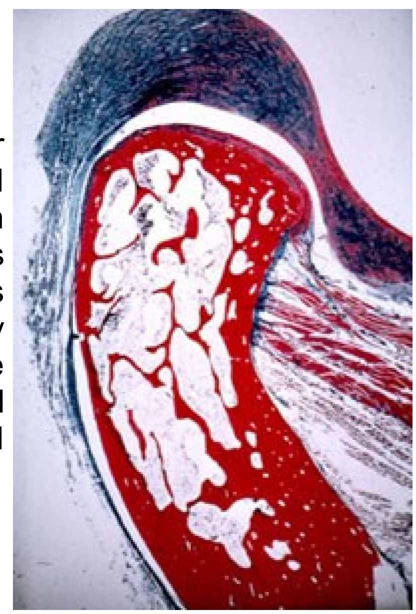
Temporomandibular Joint

The temporomandibular joint (TMJ) is the synovial articulation between the mandible and the cranium (the temporal bone). Being a synovial joint, it allows considerable movement and has a joint cavity filled with synovial fluid lines the internal surface of the joint capsule. Unlike most other synovial joints, the joint space is crossed by an articular disc and the articular surfaces are not comprised of hyaline cartilage but of fibrous tissue. It is an oval, avascular, noninnervated plate that is firmly attached to the medial and lateral collateral ligaments. The disc is biconcave in sagittal section, with a thin intermediate zone, a thick anterior band, and a thick posterior band.

The disc divides the joint space into two compartments: a lower one between the condyle and the disc and an upper one between the disc and the temporal bone. In the lower joint space rotational movement about an axis through the heads of the condyles permits opening of the jaws; this is designated as a hinge movement. In the upper joint space, because of the firm attachment of the disc to the lateral and medial poles of the condyle and the contraction of the inferior head of the lateral pterygoid muscle, a translatory movement occurs as the discs and the condyles traverse anteriorly along the descending slopes of the articular eminences to produce an anterior and inferior movement of the mandible.

Temporomandibular Joint

Image 187 Decalcified Section

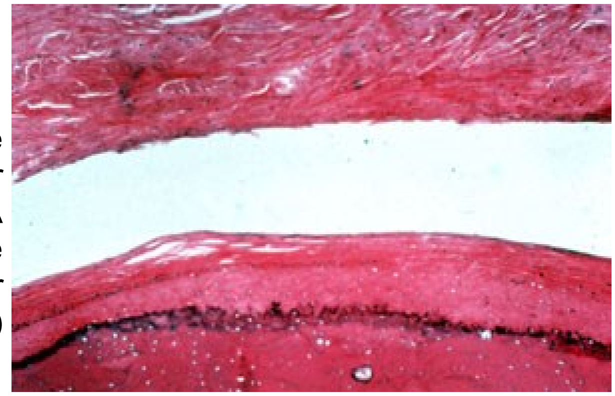


The biconcave articular disc (meniscus) is located superior to the head of the mandibular condyle. The disc is divided into anterior, middle and posterior sections which vary in thickness. The superior joint cavity (temporodiscal cavity) is located between the temporal bone lacking in this preparation) and the meniscus. The inferior joint cavity (condylodiscal cavity) is located between the head of the condyle and the meniscus. A portion of the lateral pterygoid muscle inserts onto the anterior surface of the condyle and onto the articular disc. Mallory's Trichrome, 3X

Articular Disc

Image 188

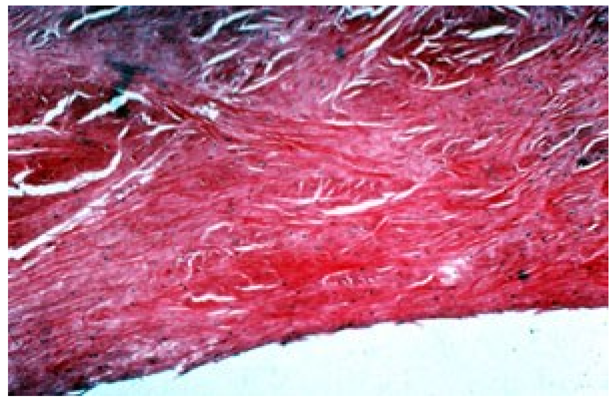
The articular disc is a dense fibrous structure which may contain cartilage in older specimens (chondroid transformation). A dense layer of fibrous tissue covers the articular surface of the condyle. A similar fibrous layer lines the mandibular (glenoid) fossa of the temporal bone. H&E, 40x



Articular Disc

Image 189

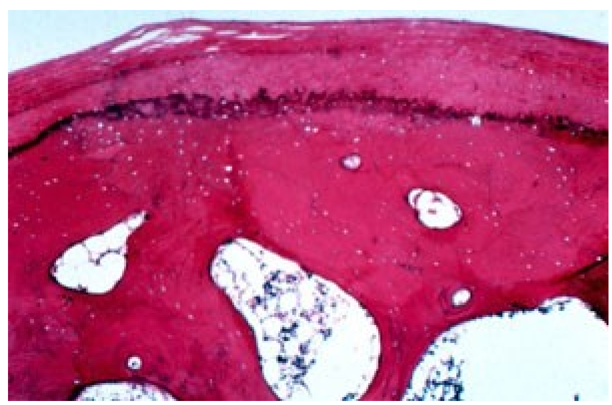
The portion of the articular disc displayed consists of an avascular, dense meshwork of collagen fibers. H&E, 40x



Condyle Head

Image 190 Decalcified Section

Identify the articular fibrous layer, cartilage layer, calcification zone, compact cortical bone and spongiosa of the condyle head H&E, 40x

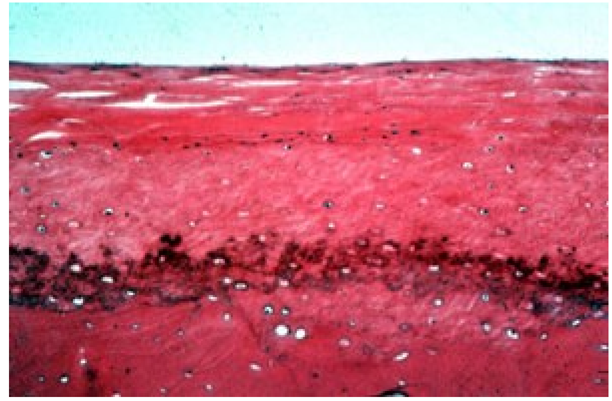


Condyle Head

Image 191

Decalcified Section

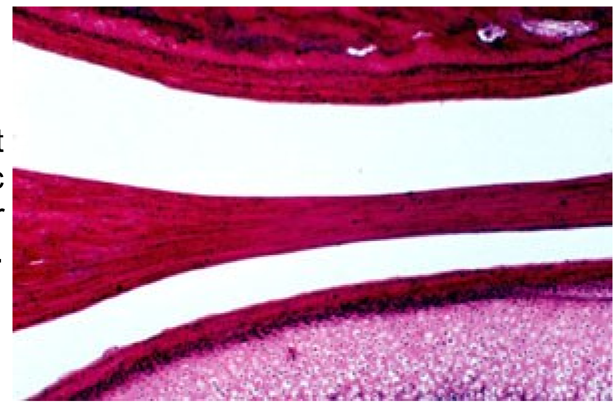
Higher power of image 188. H&E, 100x



Articular Disc

Image 192

The anterior aspect of the joint is facing the left border of the image. The articular disc separates the joint cavity into a superior synovial cavity and an inferior synovial cavity. H&E, 40x

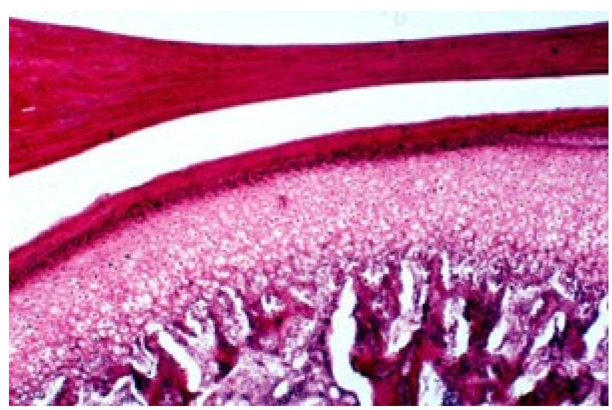


Condyle Head

Image 193

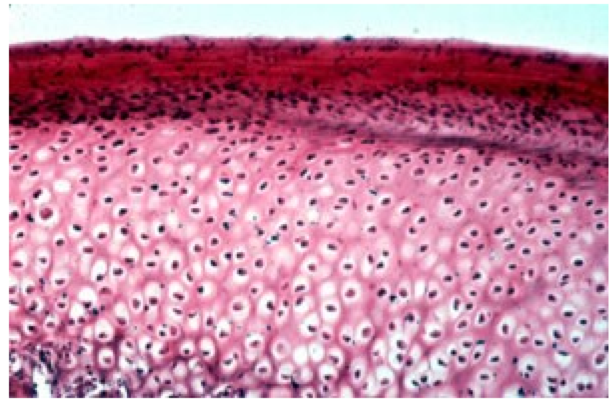
Decalcified Section

In this specimen the head of the condyle is undergoing endochondral bone formation. H&E, 40x



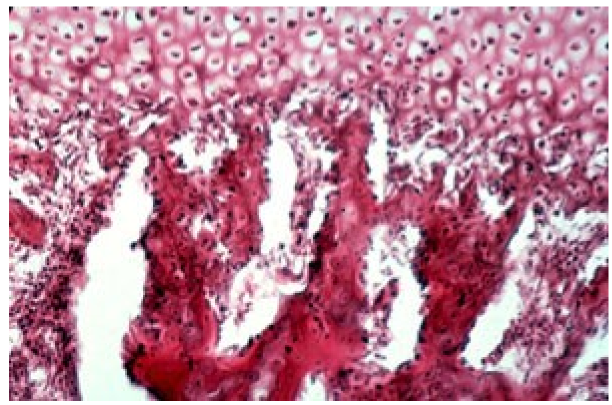
Developing Condyle
Image 194
Decalcified Section

Higher power of image 193. Developing condyle head. H&E, 100x



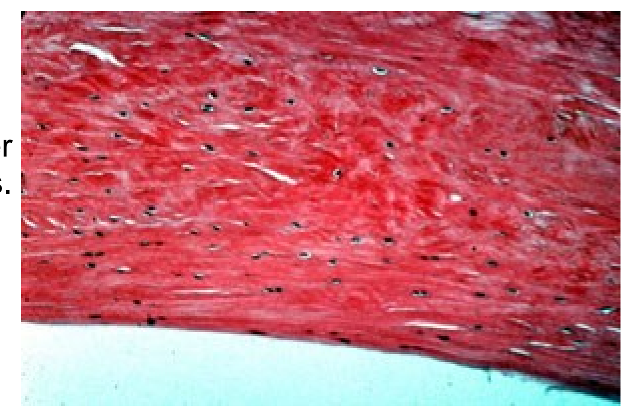
Developing Condyle
Image 195 Decalcified Section

Developing condyle head; inferior to the image 193. H&E, 100x



Articular Disc
Image 196

Notice the orientation of the collagen fiber bundles and the types and distribution of cells. Higher magnification of image 189. H&E, 100x



Oral mucous membrane

The structure of the oral mucous membrane resembles the skin in many ways. It is composed of two layers, epithelium and connective tissue. The connective tissue component of oral mucosa is termed the lamina propria. The comparable part of skin is known as dermis.

The two layers form an interface that is folded into corrugations. Papillae of connective tissue protrude toward the epithelium carrying blood vessels and nerves. Although some of the nerves actually pass into it, the epithelium does not contain blood vessels. The epithelium in turn is formed into ridges that protrude toward the lamina propria. These ridges interdigitate with the papillae and are called epithelial ridges.

Epithelium

The epithelium of the oral mucous membrane is of the stratified squamous variety. It may be keratinized, or nonkeratinized, depending on location. In humans the epithelial tissue of the gingiva and the hard palate (masticatory mucosa) are keratinized. The cheek, faucial, and sublingual tissues are normally nonkeratinized.

Keratinized oral epithelium has four cell layers: basal (stratum basale), spinous (stratum spinosum), granular (stratum granulosum), and cornified (stratum corneum).

Nonkeratinized epithelia differ from keratinizing epithelia primarily because they do not produce a cornified surface layer. The layers in nonkeratinizing epithelium are referred to as basal (stratum basale), intermediate (stratum intermedium), and superficial (stratum superficiale).

Lamina propria

The connective tissue underlying the oral epithelium can be described as having two layers: papillary layer between the epithelial ridges, in which the collagen fibers are thin and loosely arranged; and, beneath this, a deep, reticular layer dominated by thick, parallel bundles of collagen fibers.

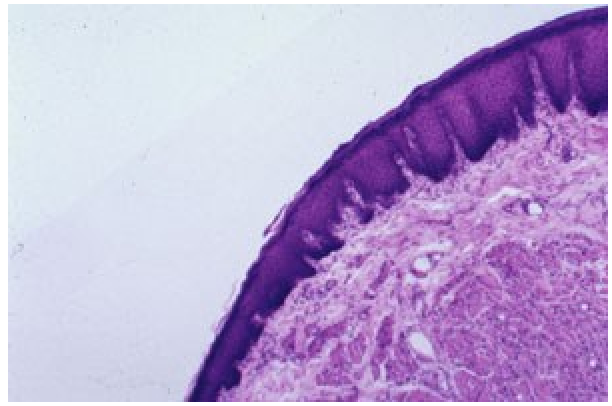
The ground substance of the lamina propria consists of an hydrated gel of glycosaminoglycans. Embedded in the ground substance are collagen fibers (mainly Type I, with a little Type III), elastic fibers and fibronectin. Thin oxytalan fibers have also been found in the lamina propria.

Submucosa

The submucosa consists of connective tissue of varying thickness and density. It attaches the mucous membrane to the underlying structures. Whether this attachment is loose or firm depends on the character of the submucosa. The boundary between lamina propria and submucosa is indistinct, in many regions of the mouth, the submucosa is absent. When present, it is containing some fat cells , a variable number of minor salivary glands, blood vessels, and nerves.

Skin - Vermilion Junction

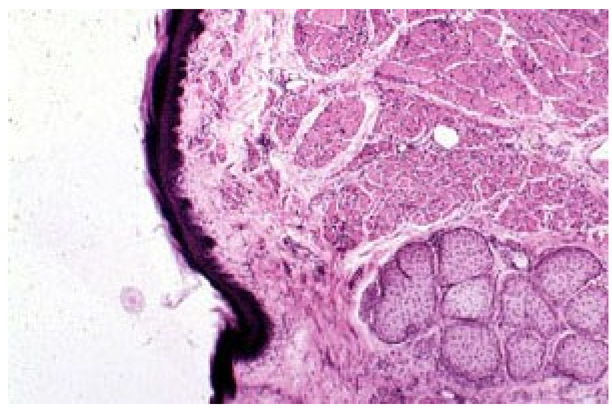
Image 197



The red zone of the lip, which is located between the skin and the oral mucosa proper, is termed the vermilion border. It is characterized by a thinly keratinized stratified squamous epithelium and very prominent rete ridges. The vermilion border lacks hairs and sweat glands, which occur in the skin, but may contain sebaceous glands. Notice the proximity of the tall connective tissue papillae to the surface of the epithelium. The blood vessels of the papillae tend to have relatively wide lumens. H&E, 40x

Lip, Skin Surface

Image 198 Sagittal Section

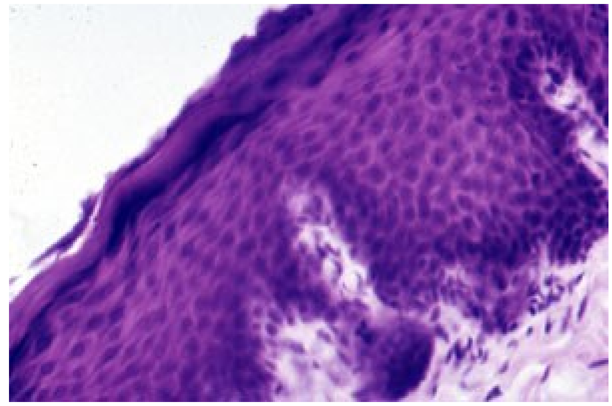


The external surface of the lip is covered by thin skin. Fasciculi of the orbicularis oris muscle are located in the central region of the lip. The lip displays a mucocutaneous junction where the skin is continuous with the oral mucosa. H&E, 40x

Vermilion Surface

Image 199

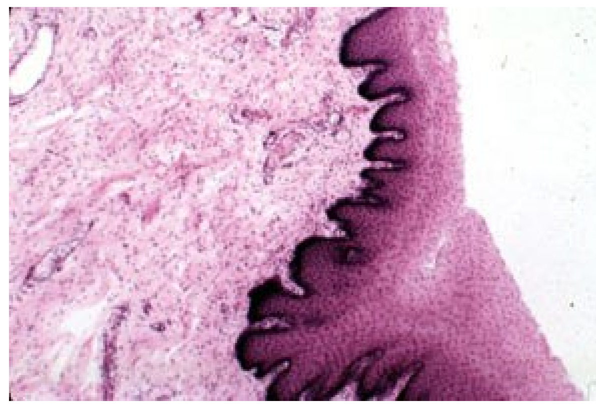
Higher power of image 197. H&E, 200x



Labial Mucosa

Image 200

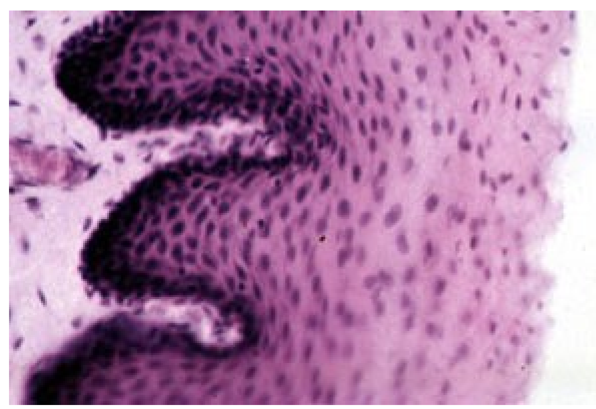
The labial mucosa is an example of a lining mucosa of the oral cavity. It is characterized by a relatively thick nonkeratinized stratified squamous epithelium and a dense lamina propria. The rete ridges and interdigitating papillae are short and somewhat irregular. H&E, 40x



Labial Mucosa

Image 201

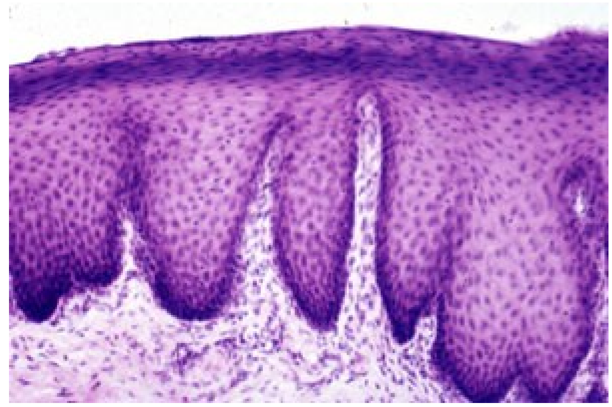
Higher power of image 200. H&E, 200x



Vermilion Border

Image 202

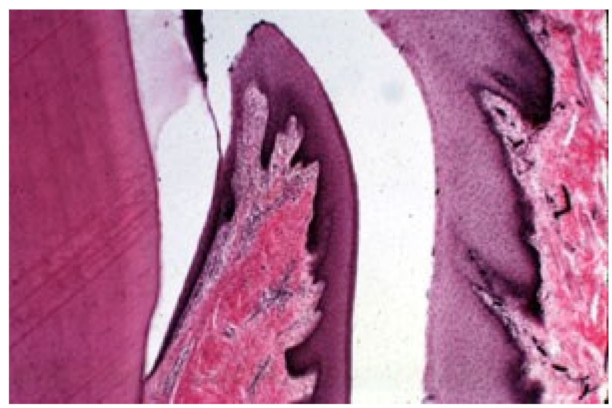
Higher power of image 197. H&E, 100x



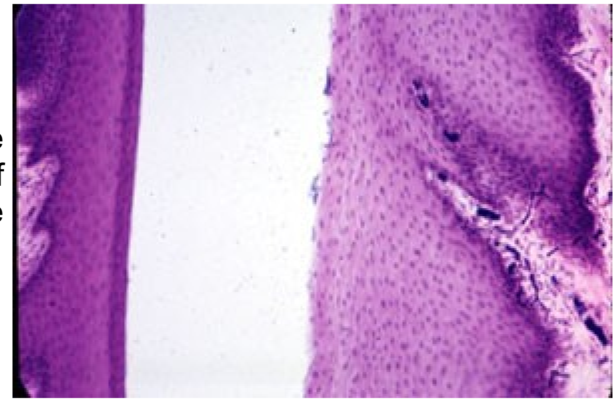
Labial Mucosa & Free Gingiva

Image 203

The labial mucosa is separated from the free gingiva by the space of the vestibule. The free gingival epithelium is usually parakeratinized stratified squamous epithelium that is supported by a dense lamina propria which lacks glands, muscle or adipose tissue. The sulcular epithelium is thin and nonkeratinized stratified squamous epithelium in tissue type. In the healthy state, a flat interface exists between the epithelium and the lamina propria at the site of the basement membrane. Observe the differences in thickness among the three epithelial linings and the differences in the relative prominence of the rete ridges. During the decalcification of the specimen for histologic preparation, the enamel is removed and is only evident as an enamel space. H&E, 40x

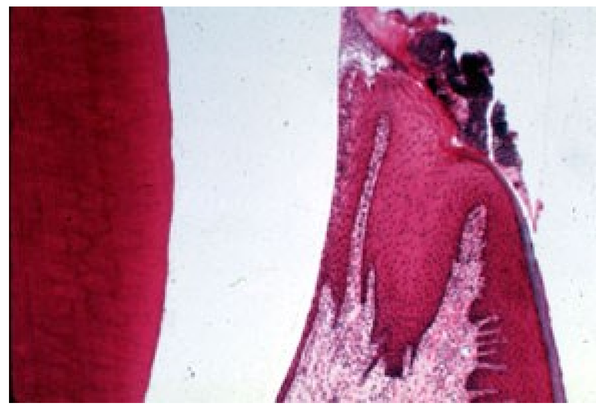


Labial Mucosa & Free Gingiva
Image 204



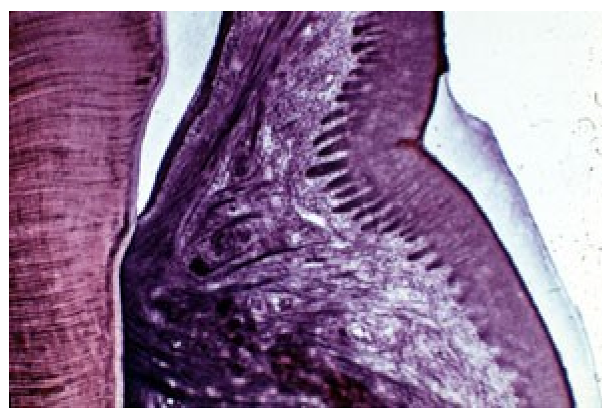
Higher power of image 203. Note the difference in thickness, degree of keratinization and staining quality between the two epithelial linings. H&E, 100x

Marginal Gingiva
Image 205



The gingiva is separated from the tooth dentin by an enamel space. Observe the histologic characteristics of the epithelium which lines the marginal gingiva. H&E, 40x

Free & Attached Gingiva
Image 206

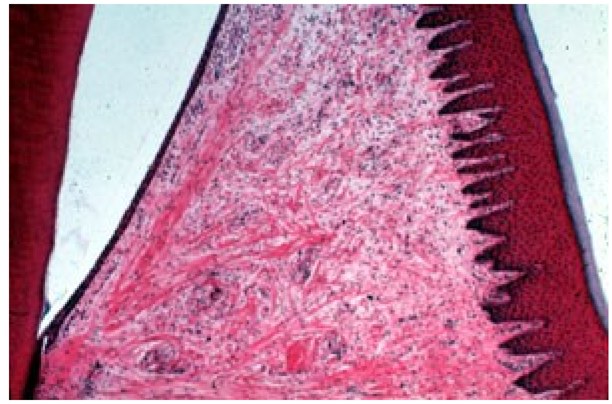


The gingiva is lined by a masticatory type mucosa. The epithelium is keratinized and is interlocked with the underlying lamina propria by tall rete ridges and connective tissue papillae, respectively. Collagen fibers of the dentogingival group of fibers extend from the cementum into the lamina propria of the gingiva. Silver Stain, 40x

Free Gingiva

Image 207

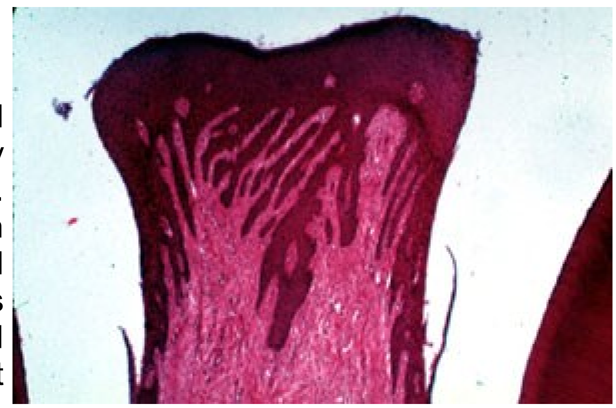
In this specimen the oral epithelium is keratinized, relatively thick and displays well developed rete ridges. The nonkeratinized sulcular epithelium is thin and has a flat, nonundulating basement membrane. H&E, 40x



Interdental Papilla

Image 208

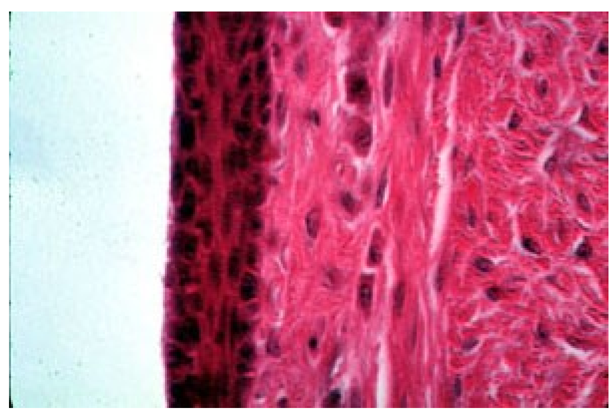
The wedge-shaped interdental papilla is lined on its mesial and distal surfaces by nonkeratinized stratified squamous epithelium. The character of the epithelium at the margin of the papilla changes along the buccolingual width of the col, being keratinized at the peaks of the col and nonkeratinized in the protected region below the contact points of the adjacent teeth. Mallory's Trichrome, 40x



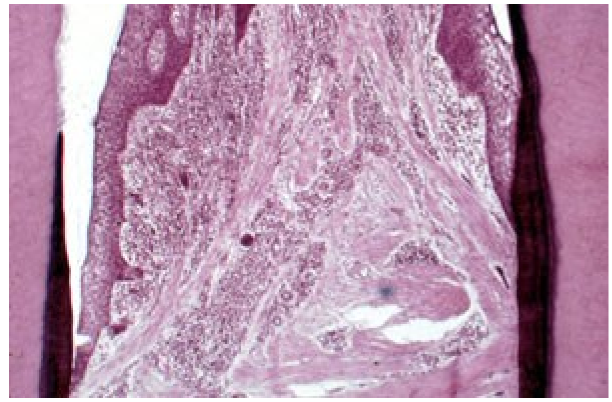
Interdental Papilla

Image 209

Higher power of image 208. The nonkeratinized sulcular epithelium is comprised of about five cell layers. Observe the flat interface between the epithelium and the lamina propria. H&E, 400x

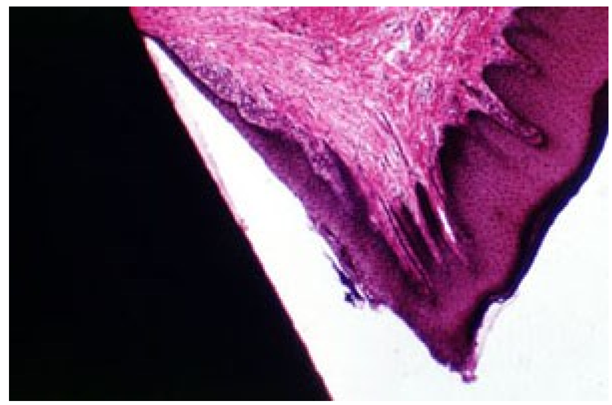


Interdental Papilla
Image 210



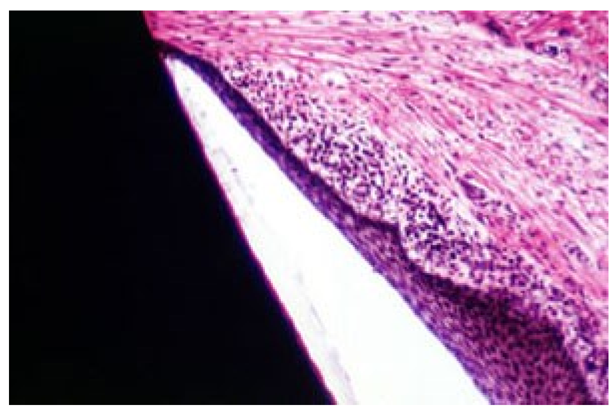
The junctional epithelium is attached to the cementum in this specimen. Note the white blood cell infiltration (round cell infiltration) and the bundles of free gingival fibers. H&E, 40x

Palatal Gingiva
Image 211



The palatal gingiva is a masticatory mucosa. It is composed of a keratinized stratified squamous epithelium that is firmly bound to the bone of the palate by dense fibrous connective tissue. Clinically, the palatal gingiva blends imperceptibly into the palatal mucosa. H&E, 40x

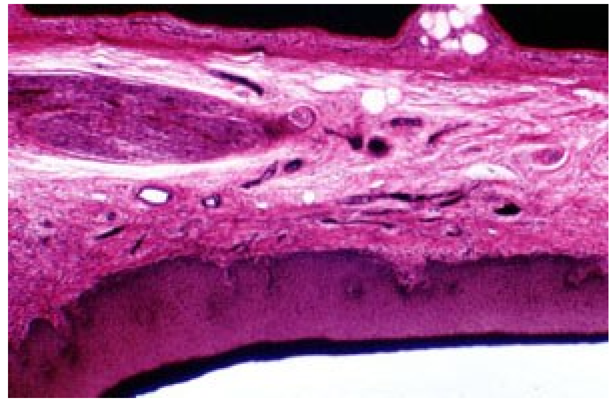
Palatal Gingiva
Image 212



Higher power 0f image 211. Magnification 100x. H&E, 100x

Hard Palate

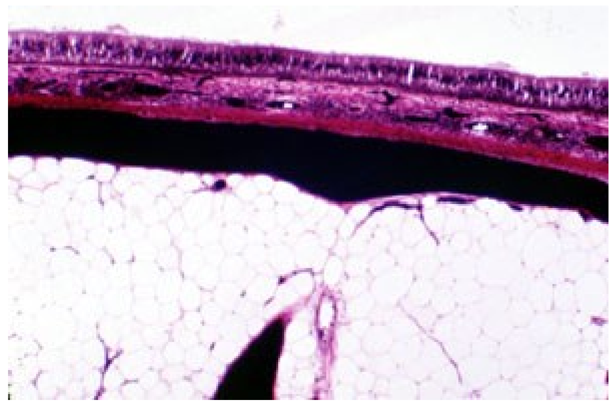
Image 213 Sagittal Section



The keratinized layer of stratified squamous epithelium is densely stained and in this specimen lacks prominent rete ridges. The lamina propria fuses directly with the periosteum of the bone (stained black). A large nerve bundle and small blood vessels are located within the lamina propria. Silver Stain, 40x

Hard Palate, Nasal Cavity Surface

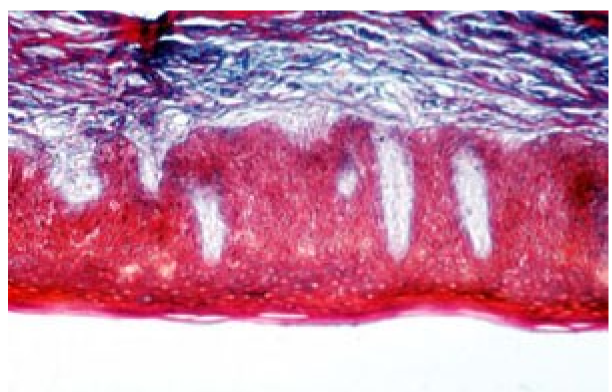
Image 214



The nasal cavity side of the hard palate is lined by ciliated pseudostratified columnar epithelium with goblet cells. Fatty bone marrow is abundant. Silver Stain, 40x

Hard Palate, Oral Cavity Surface

Image 215

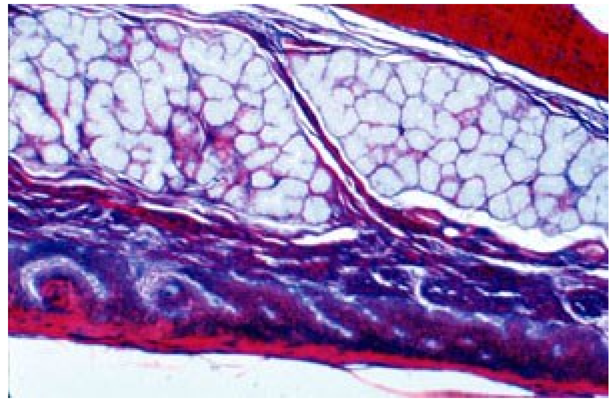


Mallory's Trichrome, 100x

Hard Palate, Glandular Zone

Image 216

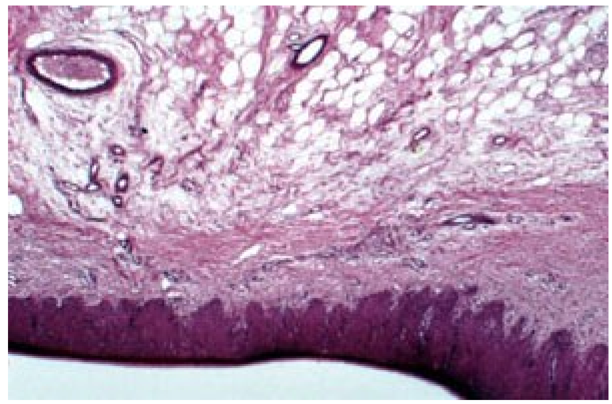
The posterior-lateral region of the hard palate which is located between the palatine raphe and the palatal gingiva is termed the glandular zone. The lamina propria is attached to the periosteum by dense strands of collagen. The submucosa contains a large number of mucous secretory acini. Mallory's Trichrome, 40x



Hard Palate, Fatty Zone

Image 217

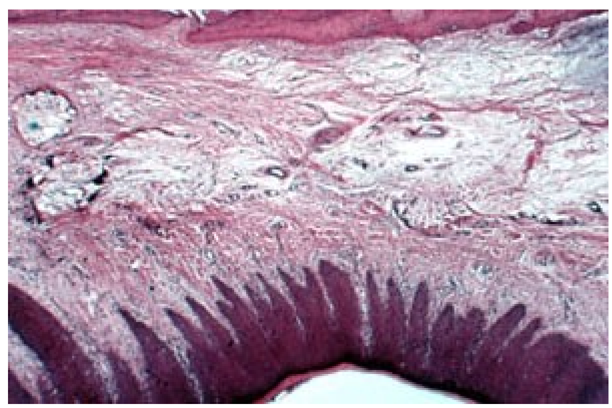
The submucosa is infiltrated with adipose tissue. H&E, 40x



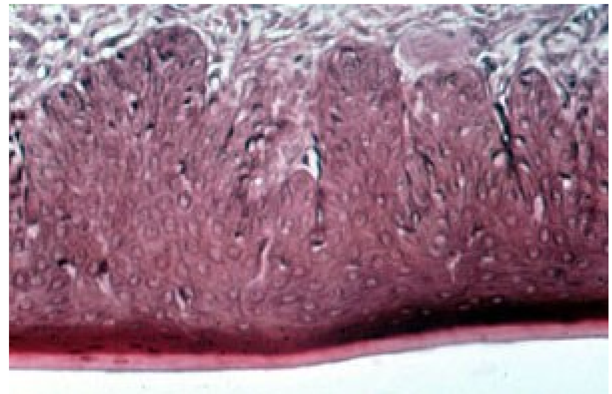
Hard Palate, Palatal Gingiva

Image 218

Another view of palatal gingiva. H&E, 40x

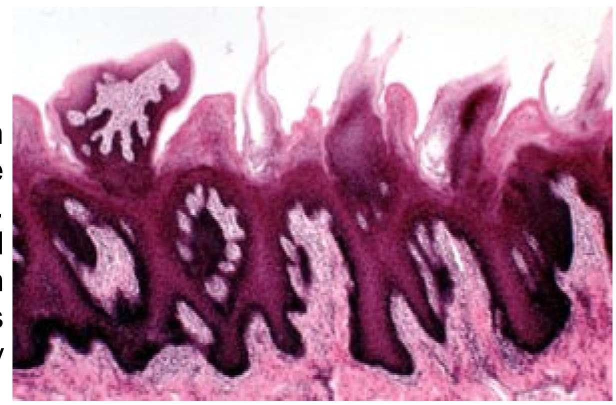


Hard Palate, Masticatory
Image 219



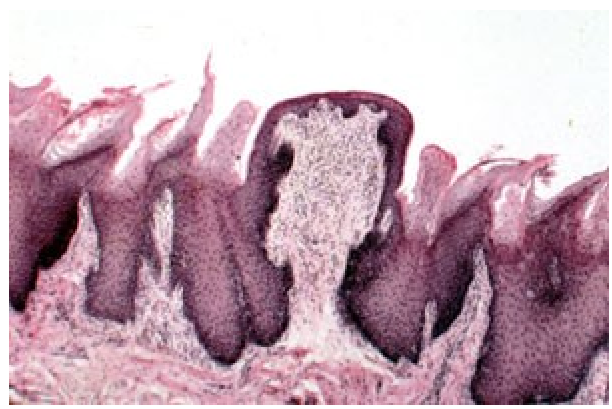
Higher power. H&E, 200x

Filiform & Fungiform Papillae
Image 220



The filiform papillae are roughly conical in shape. Each contains a small connective tissue core and a keratinized epithelial lining. The fungiform papillae are dome-shaped and contain a core of connective tissue with a rich vascular component. The lining epithelium is relatively thin and is generally thinly keratinized. H&E, 40x

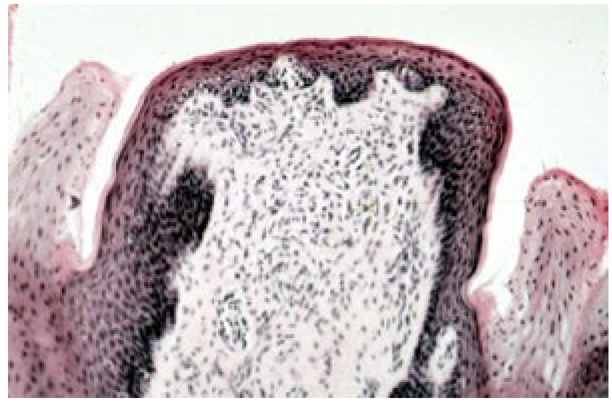
Filiform & Fungiform Papillae
Image 221



Here is another view of a fungiform papilla surrounded by filiform papillae. H&E, 40x

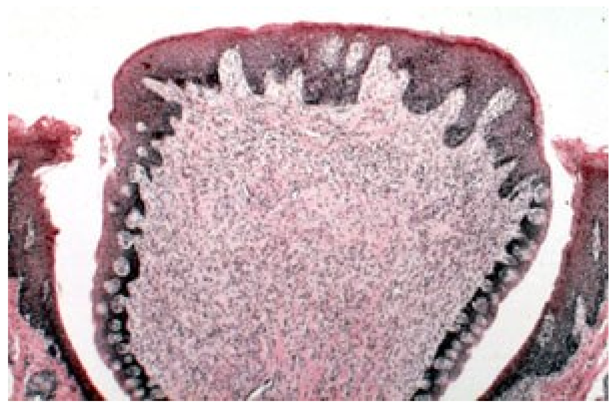
Fungiform Papilla
Image 222

This is a higher magnification view of a fungiform papilla. H&E, 100x



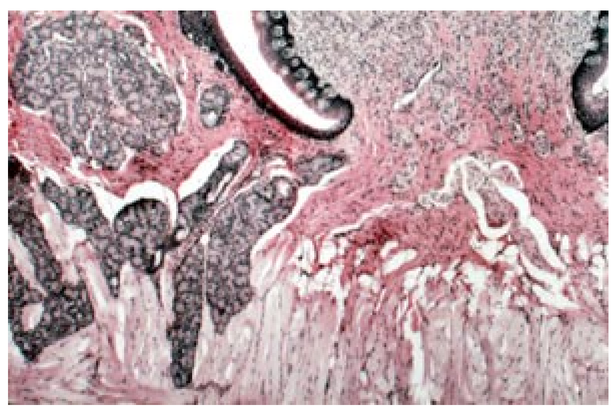
Circumvallate Papilla
Image 223

The circumvallate papillae are large mushroom-shaped structures which may be up to several millimeters in width. They are characteristically circumscribed by a trough. Numerous taste buds are located within the epithelium that lines the walls of the trough. H&E, 40x



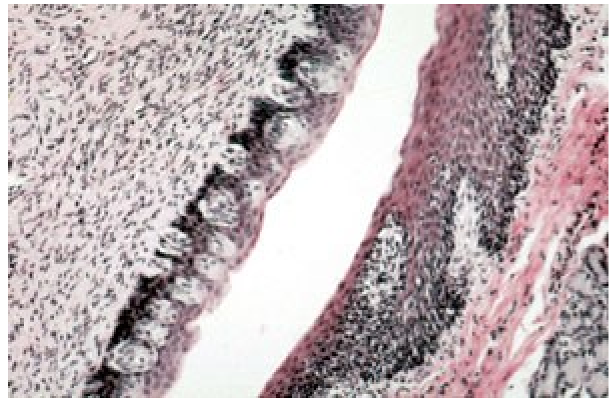
von Ebner's Glands
Image 224

The serous glands of von Ebner are located at the base of the circumvallate papilla. What is the function of the lingual von Ebner's glands? H&E, 40x



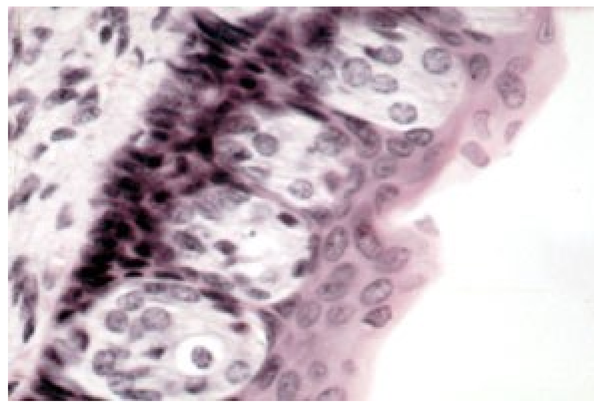
Taste Buds
Image 225

Higher power of image 223. H&E, 100x



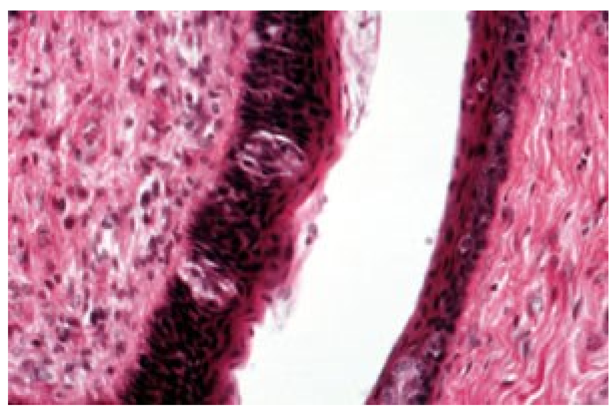
Taste Buds
Image 226

Higher power of image 225. The taste buds appear as ovoid-shaped structures within the epithelial lining of the papilla. It consists of sustentacular (supporting) cells and gustatory neuroepithelial (taste) cells. A taste pore exits onto the surface of the epithelium from each taste bud. H&E, 400x



Taste Buds
Image 227

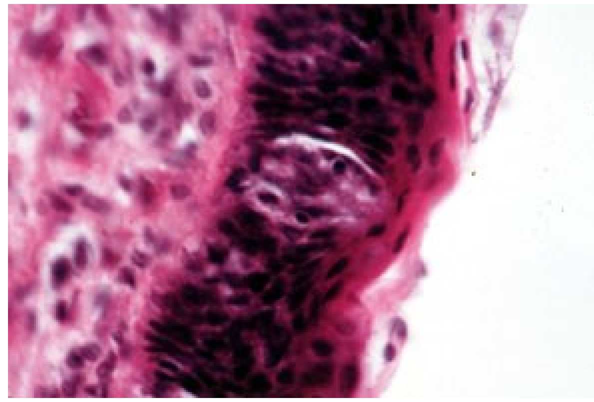
Higher power. H&E, 200x



Taste Buds

Image 228

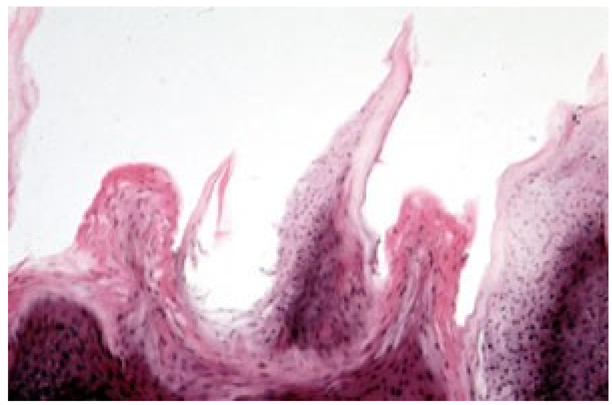
Higher power of image 227. H&E, 400x



Filiform Papillae

Image 229

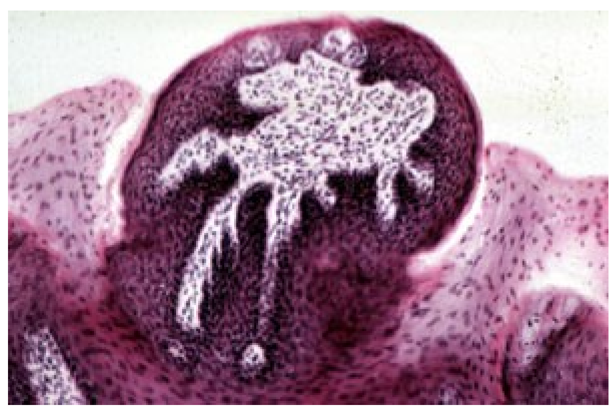
Higher power. H&E, 100x



Fungiform Papillae

Image 230

Why do fungiform papillae appear as red spots on the tongue? H&E, 100x



Salivary glands

Salivary glands are compound, tubuloacinar, merocrine, exocrine glands whose ducts open into the oral cavity. The term compound refers to the fact that a salivary gland has more than one tubule entering the main duct; tubuloacinar describes the morphology of the secreting cells; merocrine indicates that only the secretion of the cell is released; and exocrine describes a gland which secretes onto a free surface.

Saliva is over 99% water. It contains small quantities of ions and macromolecules that perform many of its important functions. Its major role is as a lubricant during mastication, swallowing and speech. Saliva brings substances into solution so that they can be tasted. It has protective function, keeping the mucosa moist and limiting bacterial activity by preventing their aggregation and by the presence of antibacterial substances (e.g. lysozyme). Saliva features help to maintain the integrity of the dental enamel. Epidermal growth factor and nerve growth factor are produced by the salivary glands, the former possibly being involved in wound healing. Immunoglobulins (IgA) are produced by plasma cells in the salivary glands, and may be part of a widespread mucosal immune system that includes lymphoid tissue in the gut and bronchi. Saliva may play a role in water balance. If the body is dehydrated, the rate of salivation is reduced. This give rise to a dry mouth, encouraging the individual to drink.

General organization of a salivary gland

From the capsule surrounding and protecting the gland pass septa which subdivide the gland into lobes. Each lobe contains numerous secretory units and each unit consists of a cluster of a grape-like structures (the acini) positioned around a lumen. A secretory acinus may be serous, mucous or mixed. It empties into an intercalated duct lined by cuboidal epithelium, which in turn joins a striated duct formed of columnar cells. Both the intercalated and striated ducts are intralobular and affect the composition of the secretion passing through them. The striated ducts empty into the relatively inert collecting ducts, which carry the saliva to the mucosal surface and which may be lined near their termination by a layer of stratified squamous epithelial cells. The collecting ducts are interlobular.

The connective tissue septa carry the blood and nerve supply into the parenchyma. Unlike endocrine glands, whose secretion may be controlled by the activity of hormones, the secretion of salivary glands is under the control of the autonomic nervous system.

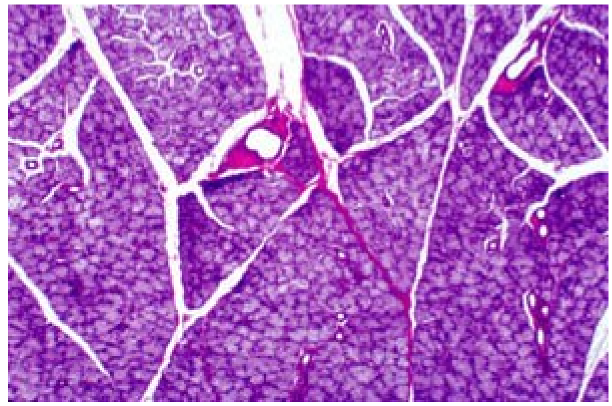
Secretory elements of the salivary glands

The serous and mucous cells of the parenchyma are responsible for the production of the primary secretion. Saliva is the product of an active secretory process and is not merely an ultrafiltrate of blood. The serous cells produce a watery proteinaceous fluid and are the source of amylase. The secretory products of mucous cells have proteins linked to a greater amount of carbohydrate, forming a more viscous mucin-rich product. Both serous and mucous cells are arranged as acini, although groups of mucous cells may have a more tubular form. Acini may contain either serous or mucous cells, or they may be mixed. When mixed, the serous cells form a cap or demilune outside the mucous cells. The secretions of the demilune pass between the mucous cells through small canaliculi to enter the lumen of the acinus. Sometimes, extensions of the demilune pass between the mucous cells to contact the lumen directly. Outside the acini, contractile cells with several processes are present. These are myoepithelial (basket) cells which, when contracted, expel preformed saliva from the lumina of the acini into the duct system.

Parencyhma

Image 231

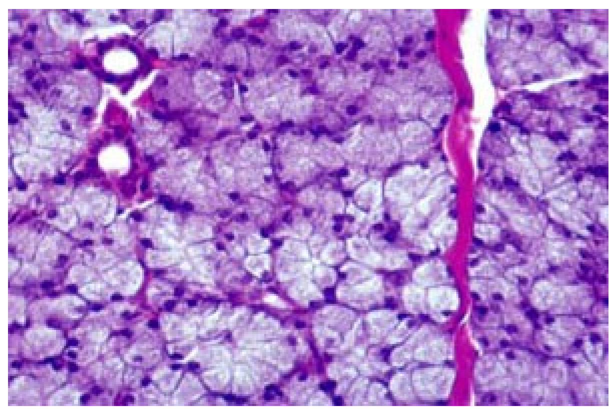
The parenchyma of the gland is divided into lobules by connective tissue septae. The spaces that occur between the lobules are artifacts of histologic preparation. Note the interlobular excretory ducts which occur in the inter-lobular septae. H&E, 40x



Serous Acini

Image 232

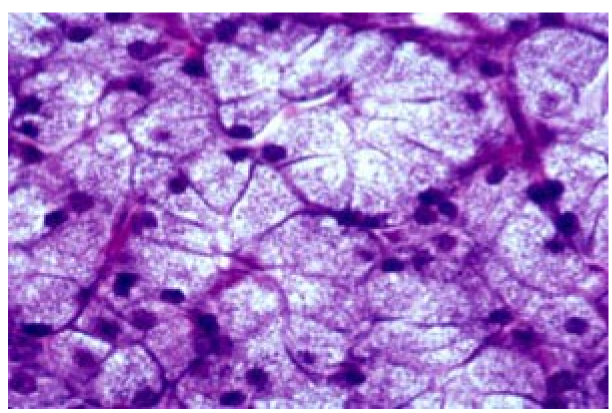
Higher power of image 231. The apical cytoplasm of serous acinar cells contains zymogen granules that give the cells a granular appearance. Notice the two intralobular ducts located at the upper left quadrant of the photomicrograph. Also observe the acidophilic low columnar cells which line the lumen of the ducts. H&E, 100x



Serous Acini

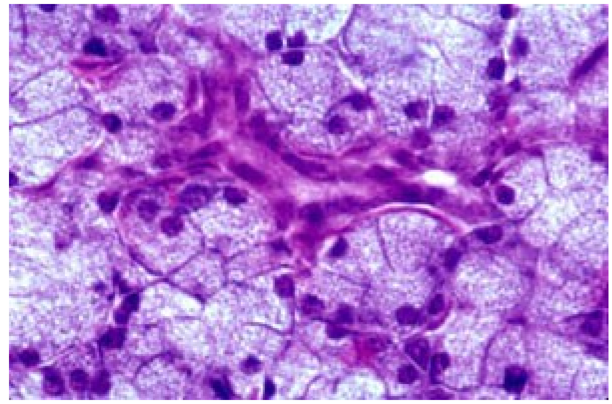
Image 233

Higher power of image 232. The serous secretory cells have round-shaped nuclei that are located in the basal end of the cells. Zymogen granules are stored in the apical cytoplasm. Note the elongated lumen of a serous acinus which is located at the top of the image. H&E, 400x



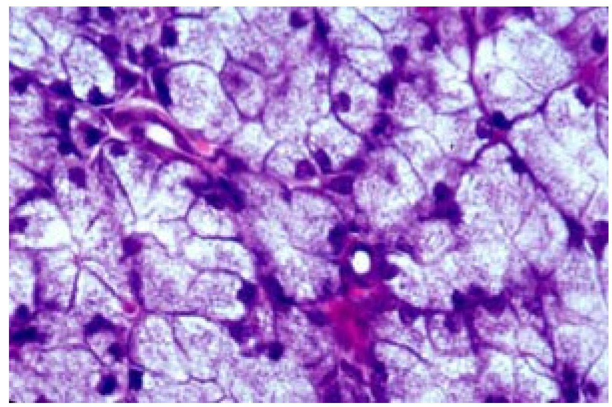
Intercalated Ducts
Image 234

Compare the cytological characteristics of the intercalated duct cells with those of the serous acinar cells. H&E, 400x



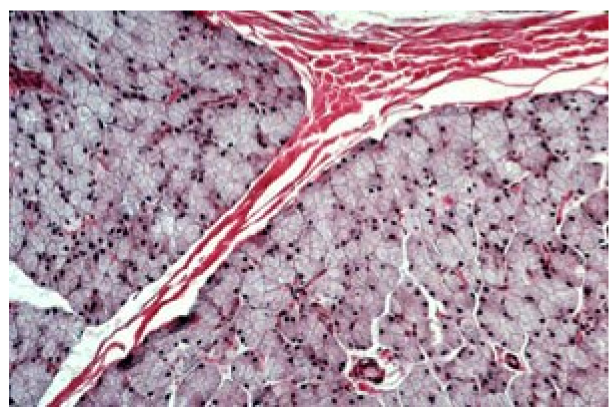
Intercalated Ducts
Image 235

Several transversely sectioned intercalated ducts are displayed. Note the small size of the tubular lumen and the type of epithelial lining. At the center of the photomicrograph an intercalated duct of larger than average diameter is present. H&E, 400x



Septae & Ducts
Image 236

Higher power of image 231. H&E, 100x



Types of salivary glands

Salivary glands may be classified according to size (major and minor) and/ or types of secretion (mucous, serous or mixed) the three paired major salivary glands are the parotid, the submandibular and the sublingual glands. The numerous minor salivary glands are scattered throughout the oral mucosa and include the labial, palatoglossal, palatal and lingual glands.

Parotid gland

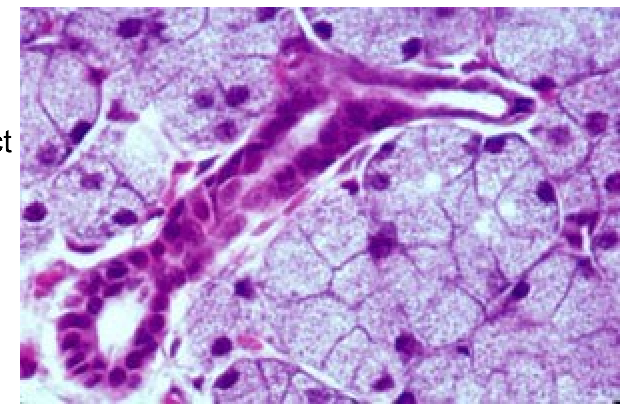
Is enclosed within a well-formed connective tissue capsule. The main excretory duct (Stensen's duct) opens into the oral cavity on the buccal mucosa opposite the maxillary second molar.

The gland is a pure serous gland. In the infant, however, a few mucous secretory units may be found. The intercalated ducts of the parotid are long and branching. The connective tissue septa contain numerous fat cells, which increase in number with age age.

Duct Junction

Image 237

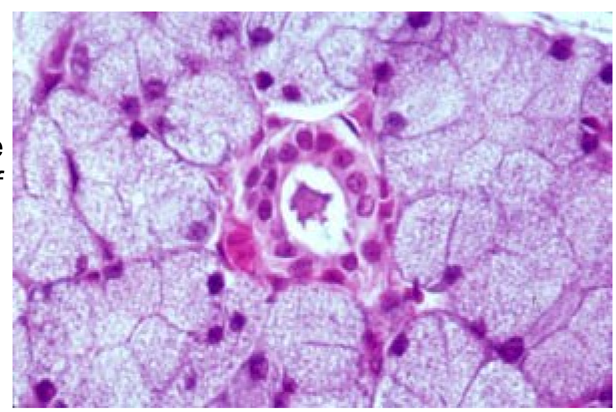
Intercalated duct-intralobular striated duct junction. H&E, 400x



Striated Duct

Image 238 Transverse Section

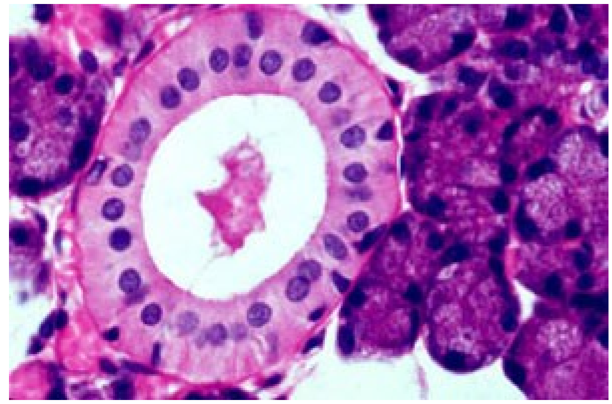
Note the precipitated secretory material in the lumen of the duct. What is the function of striated ducts? H&E, 400x



Striated Ducts

Image 239

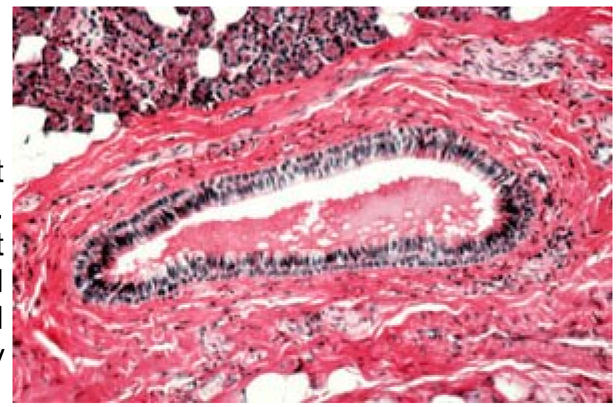
A striated duct from the previous section at higher magnification. What is the ultrastructural basis for the appearance of the striations at the light microscopic level? Note the zymogen granules within the apical cytoplasm of the serous acinar cells. H&E, 400x



Excretory Duct

Image 240

At higher magnification, a large excretory duct is located within a connective tissue septum. Nerve fibers and fat cells are also present within the septum. The excretory duct is lined by pseudostratified columnar epithelium and the lumen contains pink-stained salivary secretion product. H&E, 100x



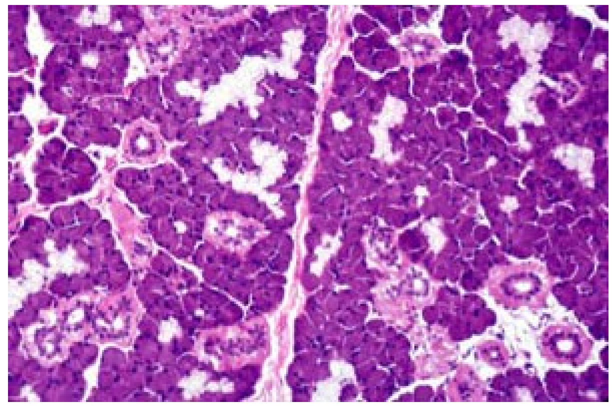
Submandibular gland

The second largest of the salivary glands, the submandibular gland produces a mixed mucous-serous secretion. Serous acini appear to outnumber mucous acini by approximately 10:1. The gland has a well-formed connective tissue capsule. The main excretory duct (Wharton's duct) opens at the side of the lingual frenum on the floor of the mouth.

The submandibular gland is a mixed gland, with both serous and mucous secretory units. The serous units predominate, but the proportions may vary from one lobule to the next.

Submandibular Gland

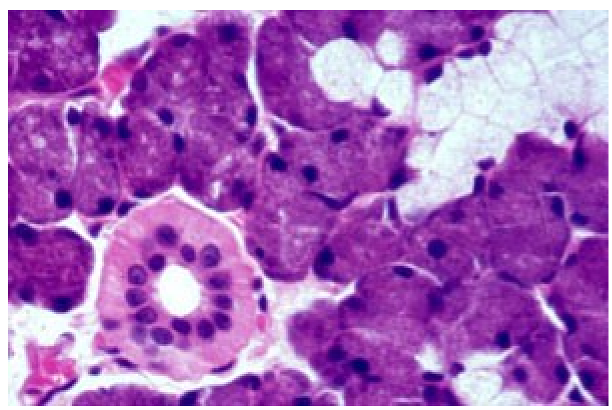
Image 241



At higher magnification, observe that there are more serous cells than mucous cells in the gland parenchyma. H&E, 100x

Mucous vs Serous

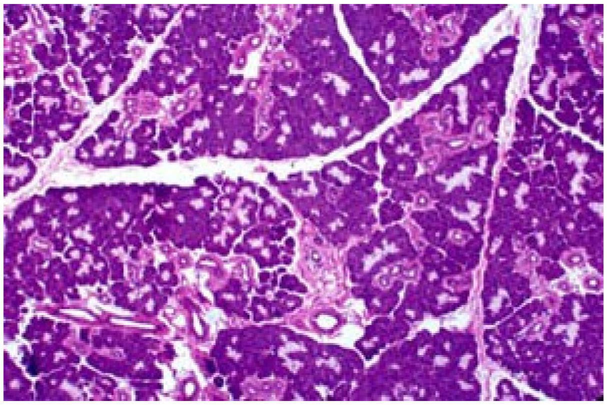
Image 242



Higher power of image 241. Observe the cytological differences between the lightly stained mucous cells and the deeply stained serous cells. In the mixed acini, the serous cells form crescent-shaped caps over the mucous cell groups and are named serous demilunes. Also observe the striated duct. H&E, 400x

Submandibular Gland

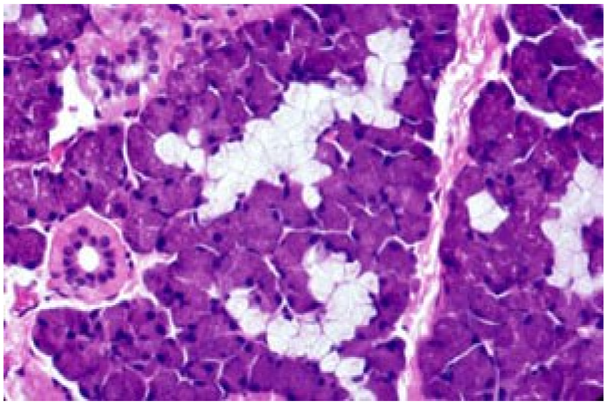
Image 243



The submandibular gland is the second largest of the salivary glands. The submandibular gland is a mixed gland; the secretory end pieces (acini) contain serous and mucous cells. Observe, however, that there are more serous cells than mucous cells in the gland parenchyma. H&E, 40x

Mucous vs Serous

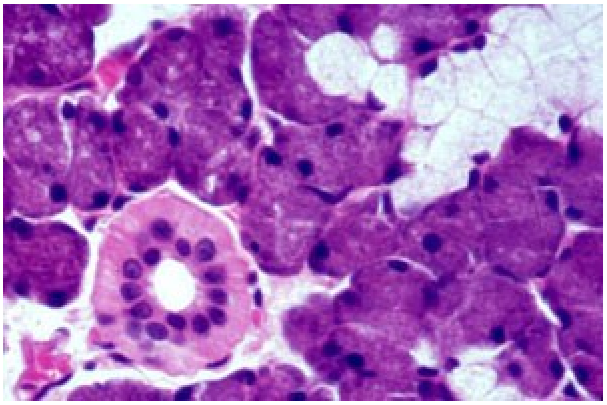
Image 244



Higher power of image 243. Observe the cytological differences between the lightly stained mucous cells and the deeply stained serous cells. In the mixed acini, the serous cells form crescent-shaped caps over the mucous cell groups and are named serous demilunes. Also observe the striated ducts. H&E, 200x

Mucous vs Serous

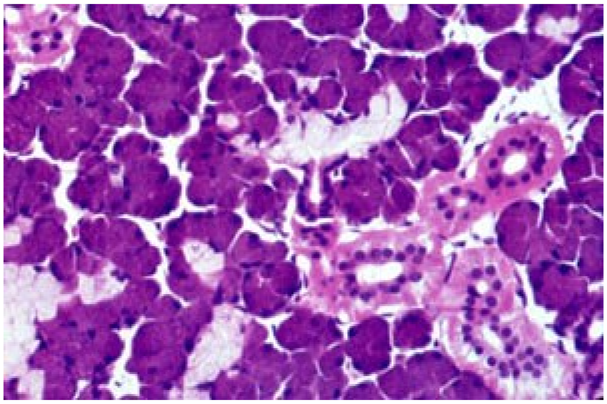
Image 245



Higher power of image 244. Observe the cytological differences between the lightly stained mucous cells and the deeply stained serous cells. In the mixed acini, the serous cells form crescent-shaped caps over the mucous cell groups and are named serous demilunes. Also observe the striated duct. H&E, 400x

Intercalated Duct

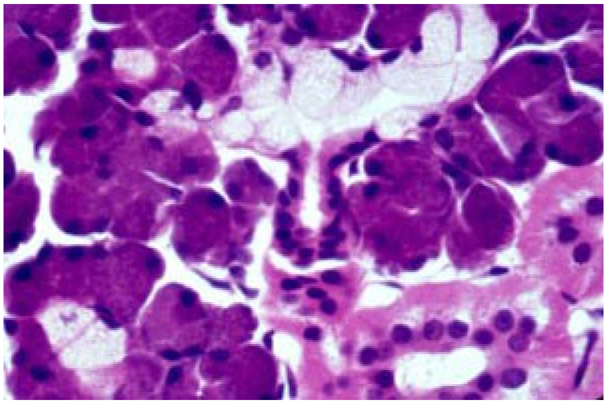
Image 246



The junction of an intercalated duct with a mucous acinus is displayed in the center of the image. Identify other histologic features of this specimen. H&E, 200x

Intercalated Duct

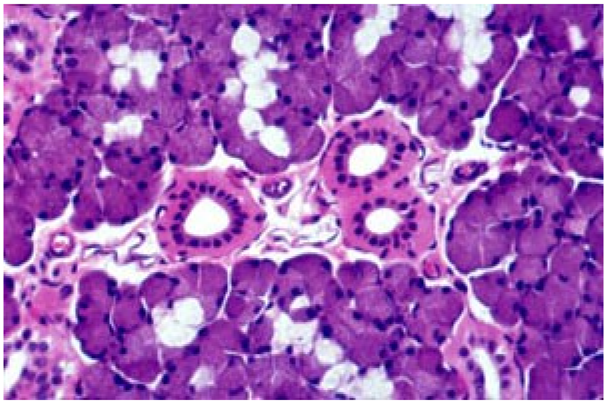
Image 247



Higher power of image 246. The junction of an intercalated duct with a mucous acinus is displayed in the center of the image. Identify other histologic features of this specimen. H&E, 400x

Striated Ducts

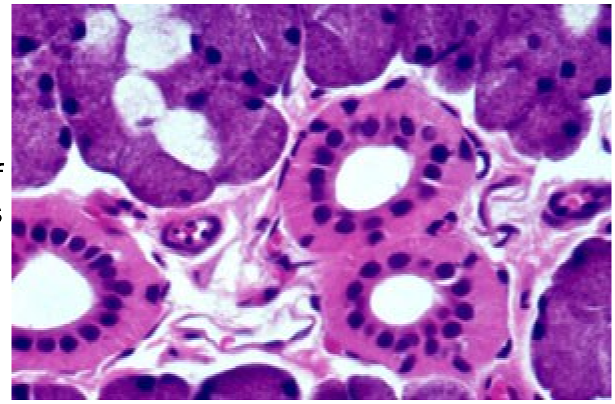
Image 248



Review the histology of the striated ducts, serous cells, mucous cells and demilunes. H&E, 200x

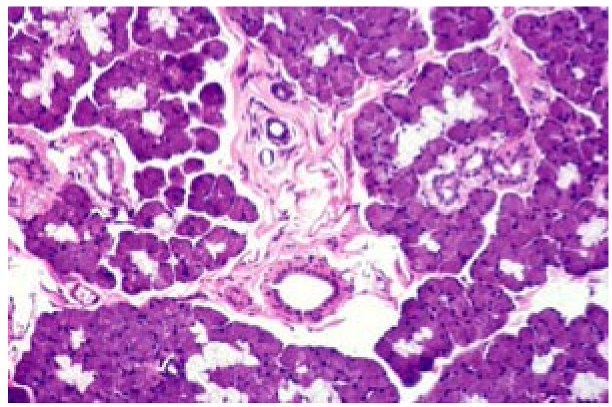
Striated Ducts
Image 249

At higher magnification, review the histology of the striated ducts, serous cells, mucous cells and demilunes. H&E, 400x



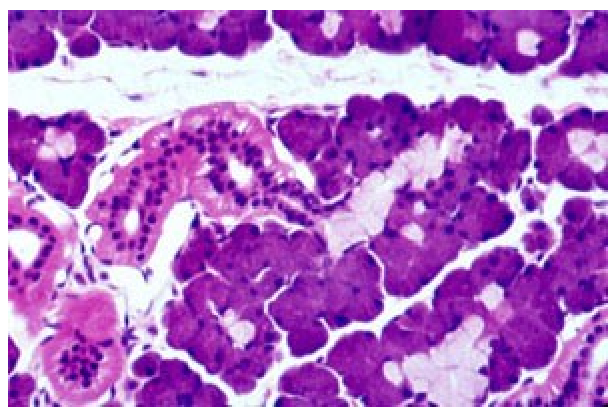
Interlobular Duct
Image 250

Note the transversely sectioned interlobular excretory duct which is located within the connective tissue septum. H&E, 100x

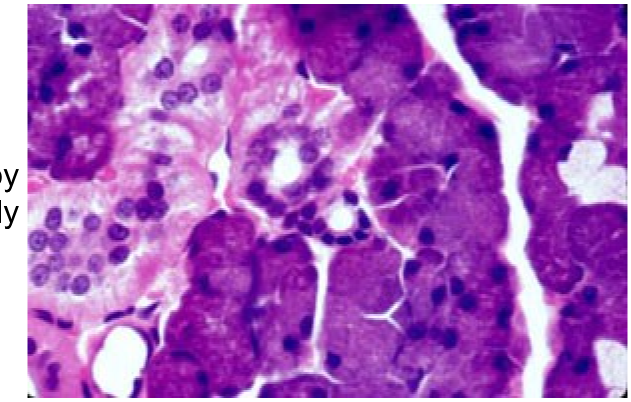


Mixed Acinus
Image 251

A mixed acinus that contains serous demilunes is continuous with an intercalated duct which, in turn, connects with a striated duct. H&E, 200x

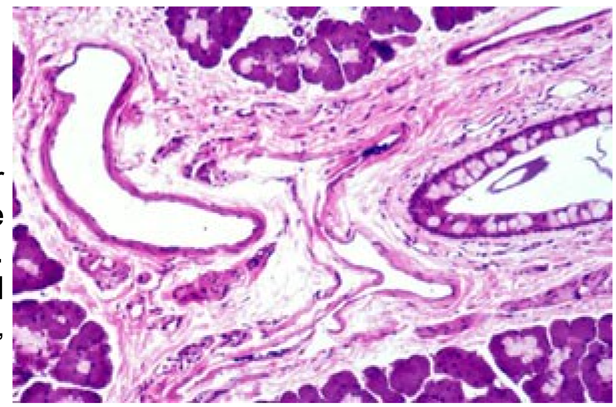


Serous Cells
Image 252



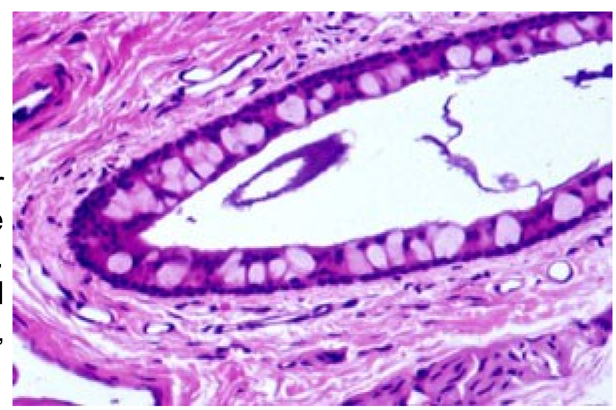
The photomicrograph is mostly occupied by serous cells. An intercalated duct is centrally located. H&E, 400x

Interlobar Duct
Image 253



At higher magnification, a large interlobar excretory duct, blood vessels and nerves are located within the connective tissue stroma. The excretory duct is lined by pseudo-stratified columnar epithelium with goblet cells. H&E, 100x

Interlobar Duct
Image 254



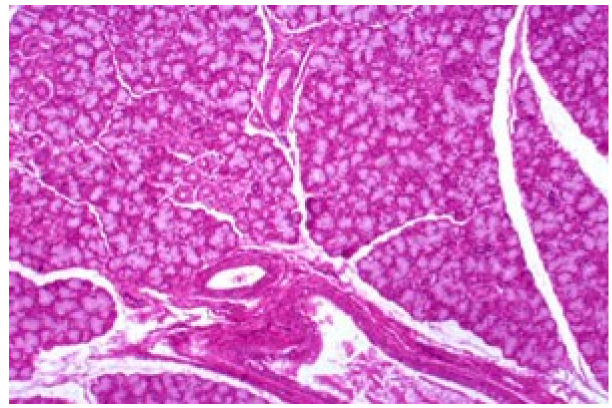
At even higher magnification, a large interlobar excretory duct, blood vessels and nerves are located within the connective tissue stroma. The excretory duct is lined by pseudo-stratified columnar epithelium with goblet cells. H&E, 200x

Sublingual gland

The human sublingual gland is not a single unit like the parotid and submandibular glands, but is made up of one large segment (the major sublingual gland) and a group of 8-30 minor glands, each having its own duct system emptying into the sublingual fold. The major sublingual gland is mixed, with more mucous than serous elements. The main duct (Bartholin's duct) opens with or near the submandibular duct.

Sublingual Gland

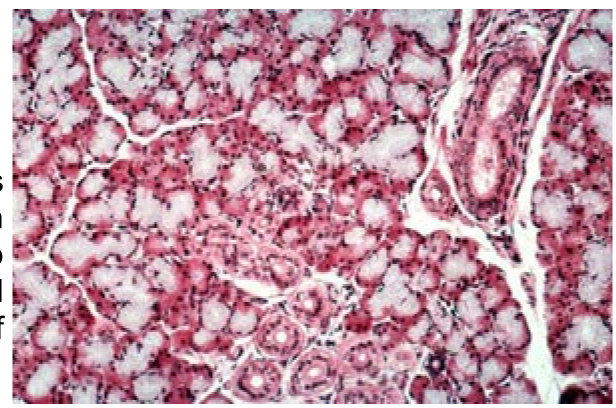
Image 255



The sublingual gland is a mixed gland. The secretory endpieces contain both serous and mucous cells, but more mucous cells. Intercalated ducts and striated ducts are sparse in the sublingual gland. H&E, 40x

Serous vs Mucous

Image 256



Notice the difference in relative numbers between the serous and mucous cells. An interlobular excretory duct is located at the top right quadrant of the image and several intralobular ducts are visible at the bottom of the image. H&E, 200x

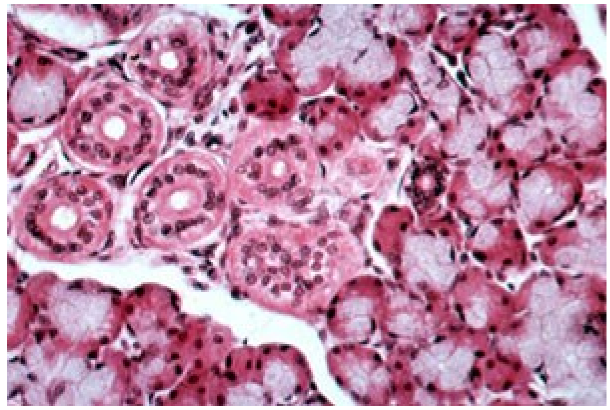
Minor salivary glands

The minor salivary glands are classified by their anatomical location: buccal, labial, palatoglossal and lingual. They are primarily mucous. The palatal glands lie in both the soft and hard palate. The anterior lingual glands are embedded within muscle near the ventral surface of the tongue, and have short ducts opening near the lingual frenum. The posterior glands are located in the root of the tongue. Both groups are mucous. The von Ebner glands empty into the trench of the circumvallate papillae are serous .

Interlobular Ducts

Image 257

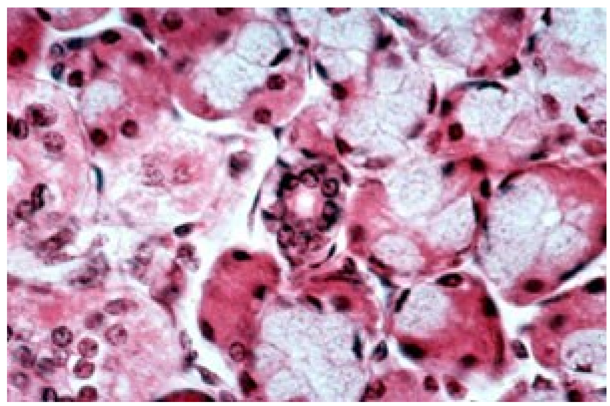
Higher power. The intralobular ducts are lined by simple columnar epithelium. The epithelial cells display centrally located round nuclei and an eosinophilic cytoplasm. H&E, 200x



Serous vs Mucous

Image 258

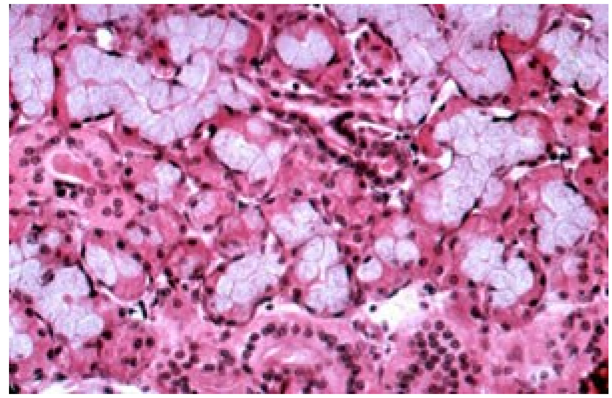
Higher power. Study the histologic characteristics of the mixed serous/mucous acini and the intercalated duct. H&E, 400x



Mucous Acinus

Image 259

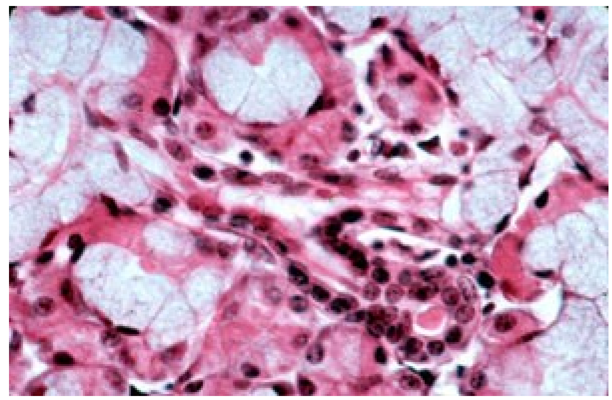
A mucous acinus is joined to a branching intercalated duct. H&E, 200x



Mucous Acinus

Image 260

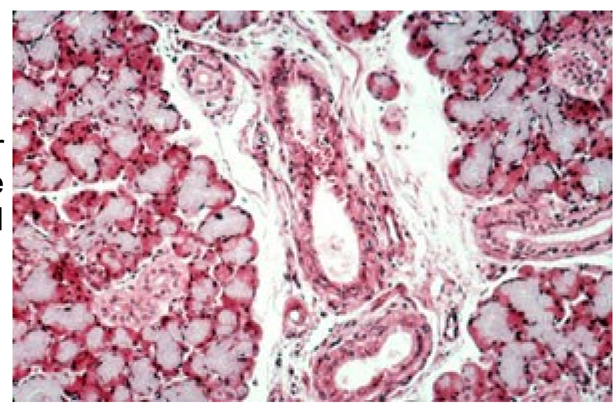
At higher magnification, a mucous acinus is joined to a branching intercalated duct. H&E, 400x



Interlobular Duct

Image 261

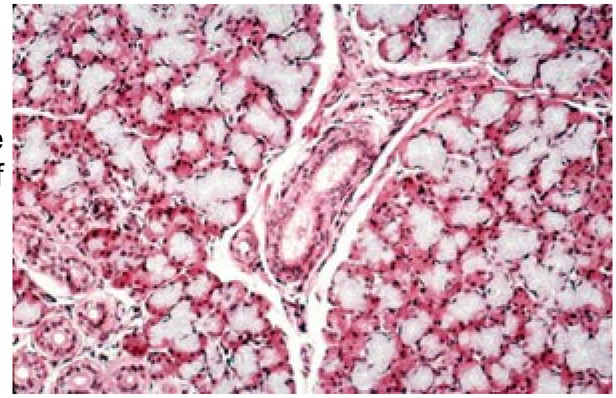
In another view, large sized interlobular excretory ducts are visible within the connective tissue stroma of the sublingual gland. H&E, 100x



Interlobular Duct

Image 262

Large sized interlobular excretory ducts are visible within the connective tissue stroma of the sublingual gland. H&E, 100x



A COLOR ATLAS OF ORAL HISTOLOGY FOR DENTAL STUDENTS

ALI.H.MURAD
BDS, MSc
Department of Oral Pathology
Thamar University
Faculty of Dentistry

Contents

Development of Oral Cavity

Odontogenesis

Dentinogenesis & Amelogenesis

Enamel

Dentin

Cementum

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Periodontal Ligament

Alveolar Bone

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Oral Mucous Membrane

Salivary Glands

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Source of Images:

Dr. William Crawford, a colleague of Tiber, digitized Dr. Tiber's original photomicrographs and descriptions and arranged these materials into this site. These files are located on the USC web server.

Preface

This atlas is not intended to be an oral histology text; many fine textbooks of oral histology are already available. However, when students enter the laboratory to identify the salient features of microscopic anatomy of oral tissue described in these texts, they find that most of them are woefully deficient in color photographs to aid them in this task. There is a particular need for photographic atlas of normal oral histology designed as a laboratory aid. It is the purpose of this atlas to meet that need. To that end, this book contains figures designed to make it easier for students to orient themselves and to locate and identify features of each tissue, as well as a minimum of descriptive text. Most tissues were photographed at low power for orientation and then at increasingly higher magnifications. No electron micrographs are included, since most textbooks provide electron micrographs where appropriate and most microscope laboratories do not offer students the use of an electron microscope. The most of the tissues are stained with hematoxylin and eosin. It is my hope that this work will serve as a valuable laboratory aid for students attempting to recognize the microscopic features of normal oral tissues and as a supplement to the many fine oral histology textbooks currently in use.

Dr. ALi.H.Murad

A COLOR ATLAS OF ORAL HISTOLOGY FOR DENTAL STUDENTS

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