

13-00

Digestive system

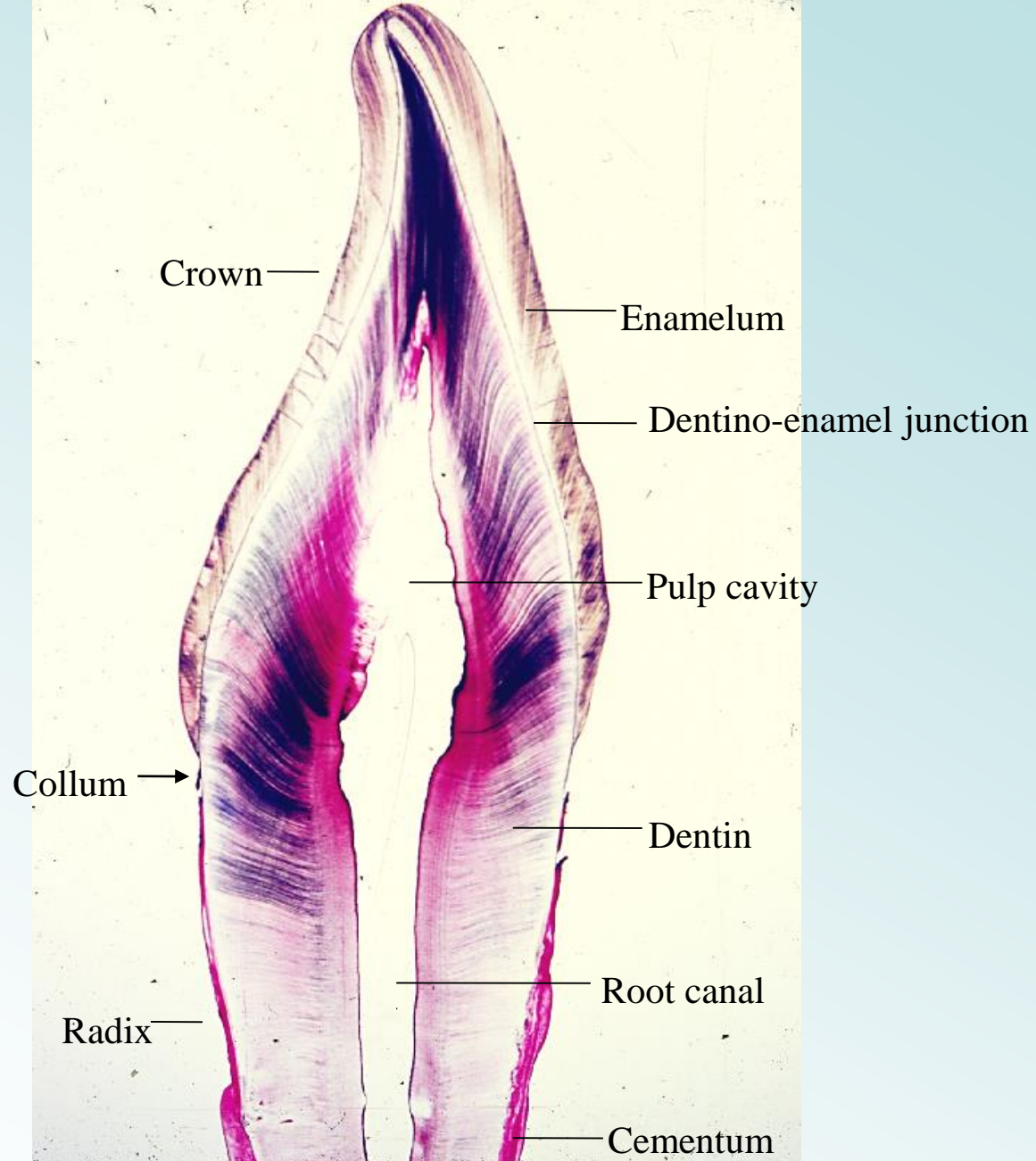
5

Teeth

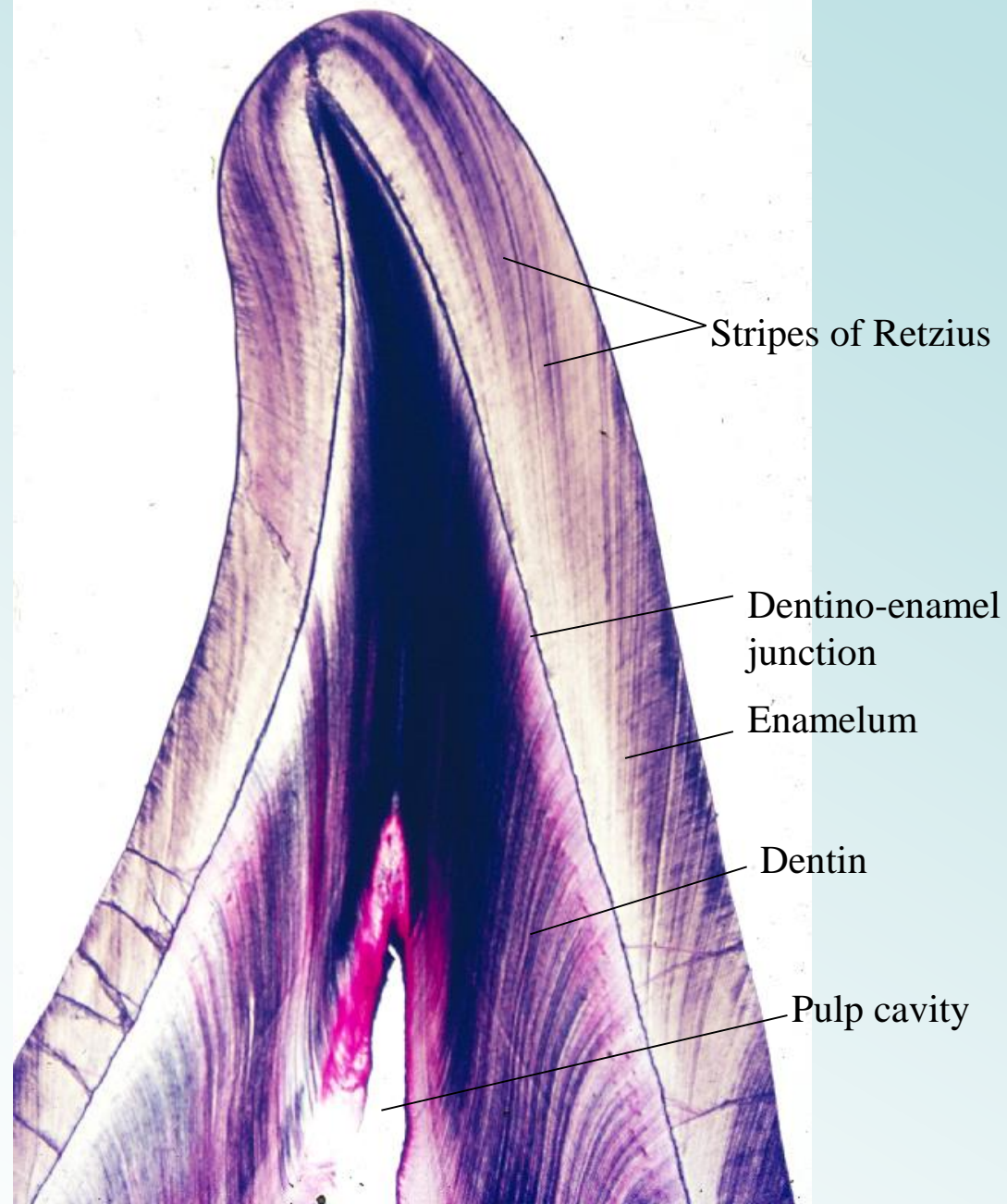
13 Digestive system 5

Menu

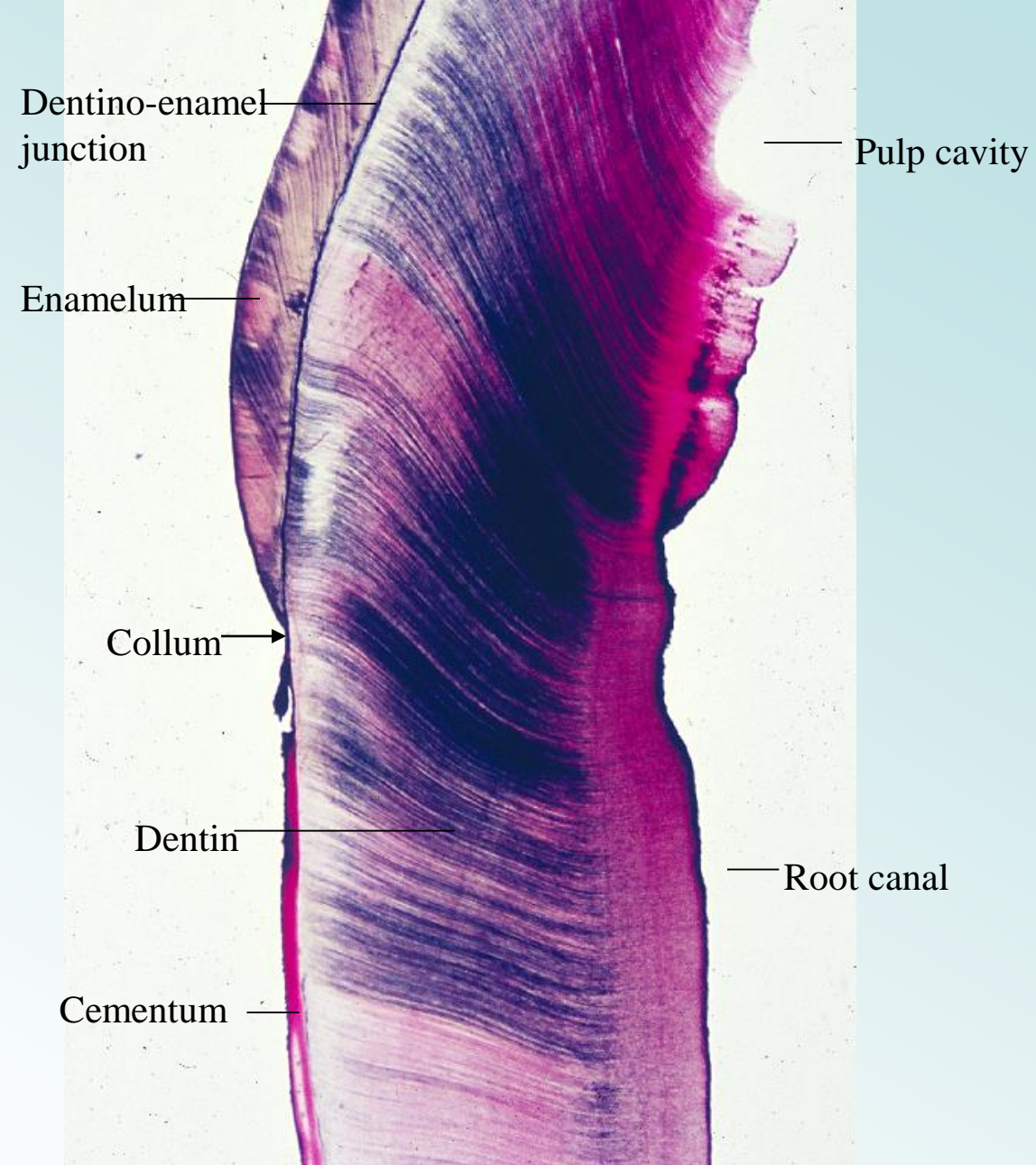
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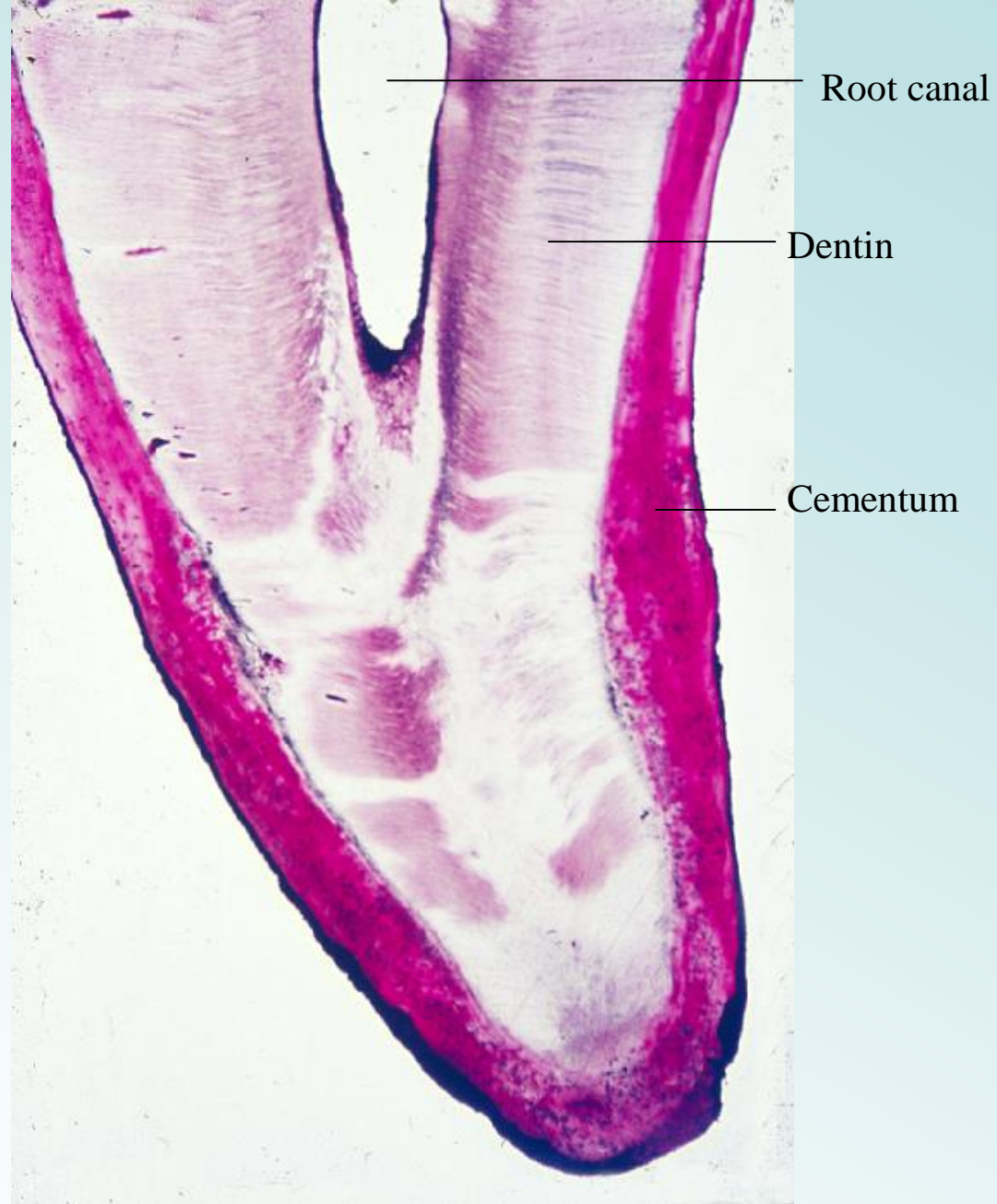
13-01 Incisor, general view. Human, longitudinal ground section, carbol-fuchsin stain, x 1.3.



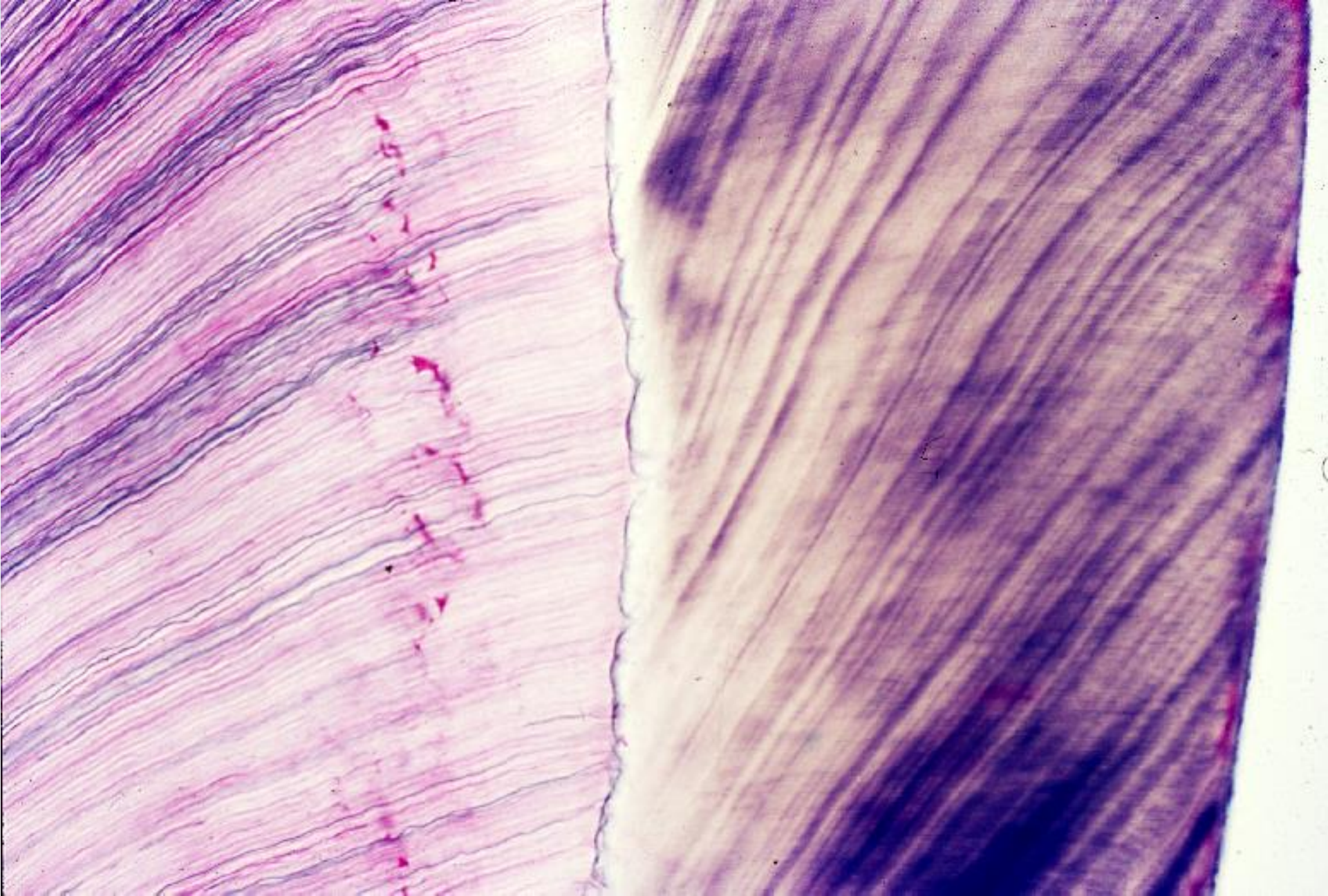
13-02 Crown of incisor. Human, longitudinal ground section, carbol-fuchsin stain. x 4.0.



13-03 Neck of incisor. Human, longitudinal ground section, carbol-fuchin stain, x 4.0.



13-04 Root of incisor. Human, longitudinal ground section, carbol-fuchsin stain, x 4.0.



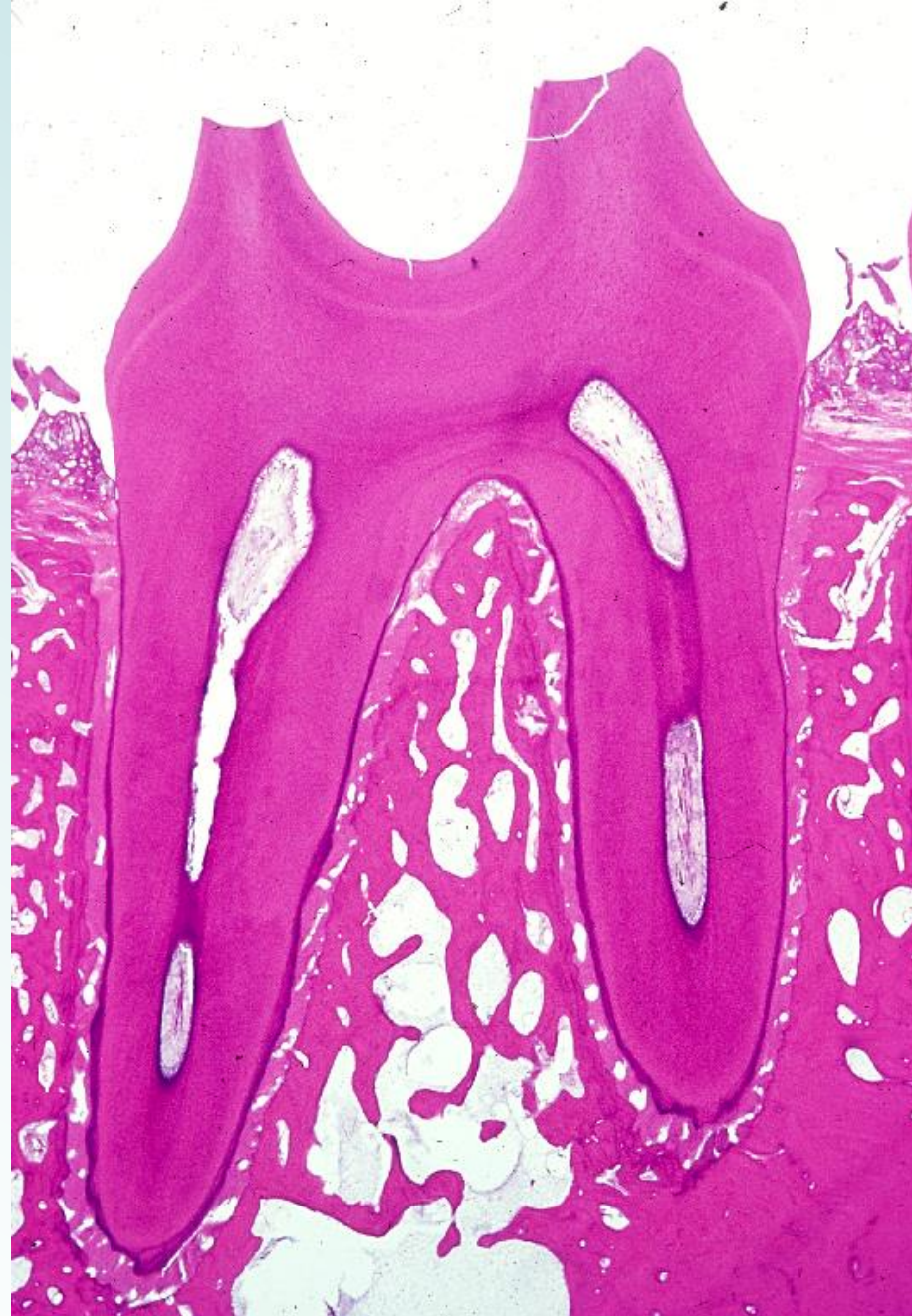
13-05 Enamel and dentin of incisor. Human, longitudinal ground section, carbol- fuchsin stain, x 25.



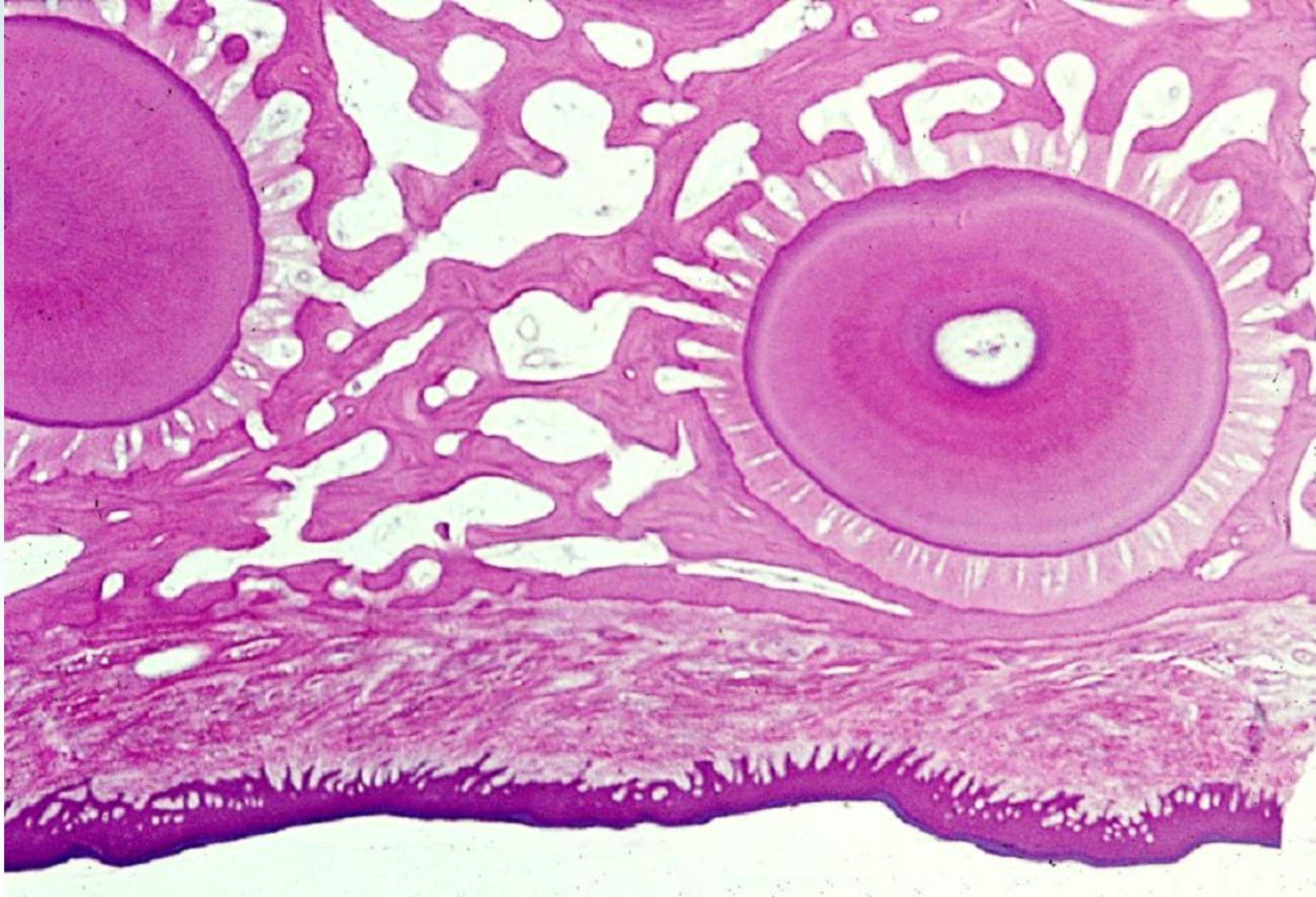
Dentin

Cementum

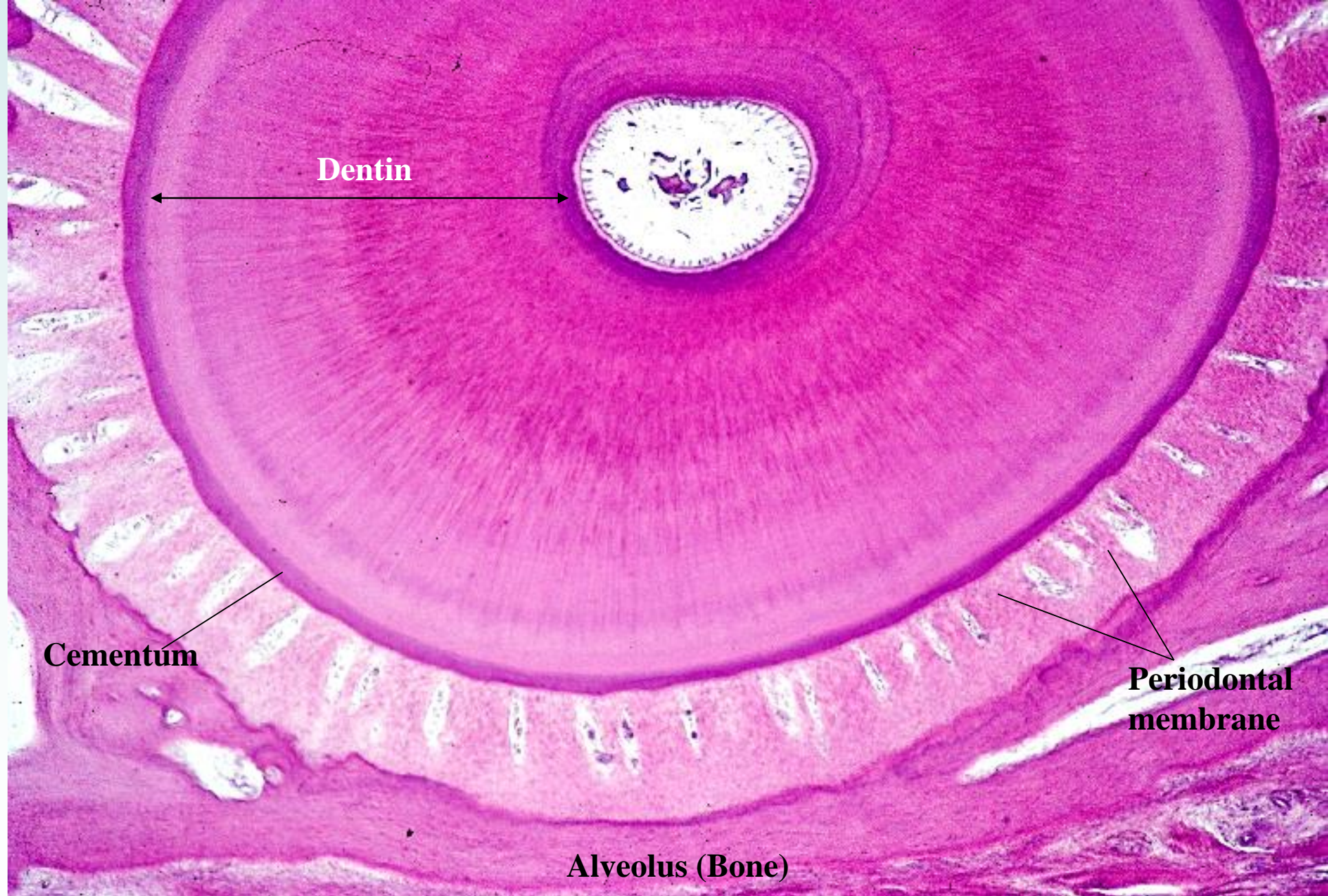
13-06 Dentin and cementum of incisor. Human, longitudinal ground section, carbol-fuchsin stain, x 25.



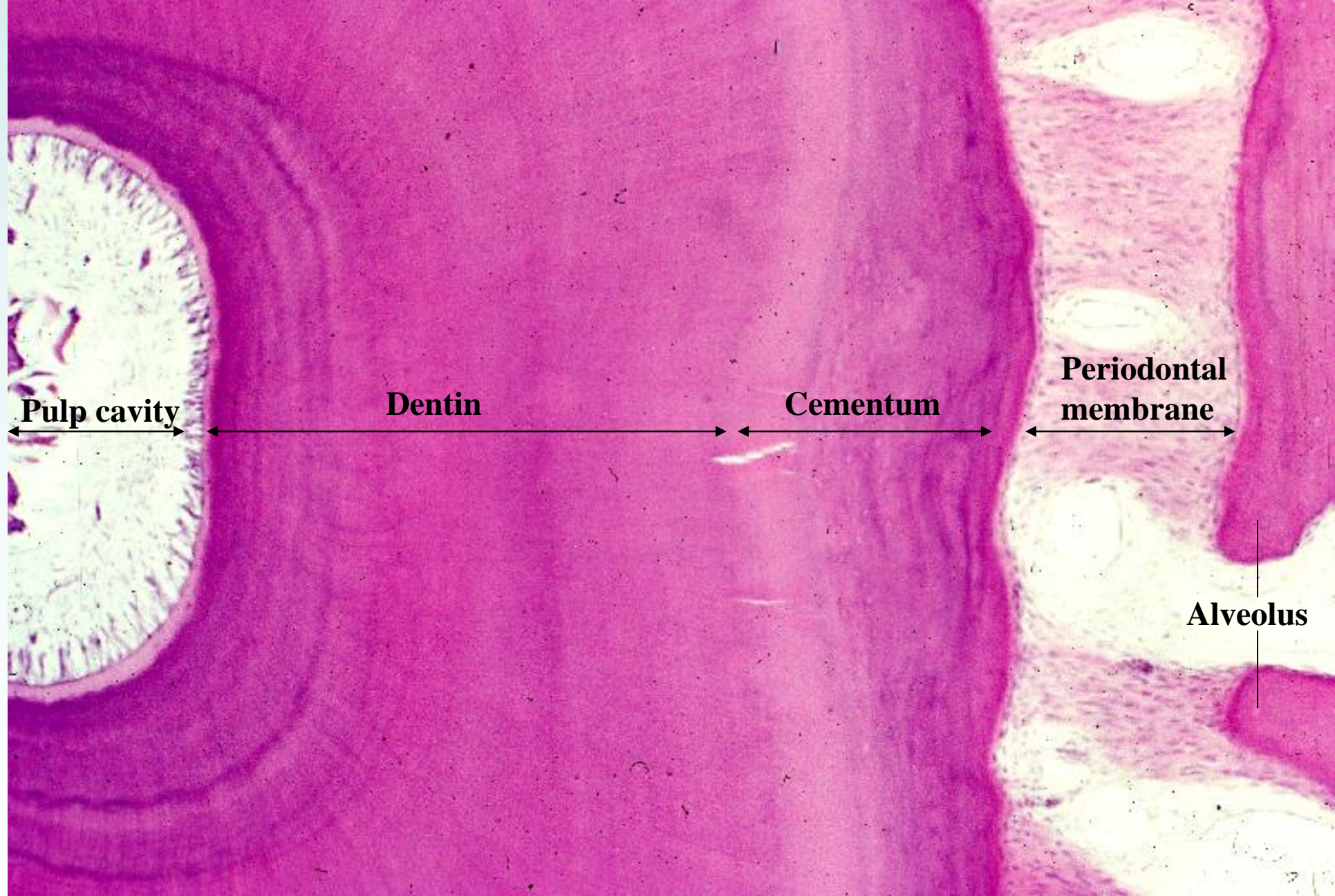
13-07 Molar in alveolus. Monkey, decalcified longitudinal section, H-E stain, x 1.5.



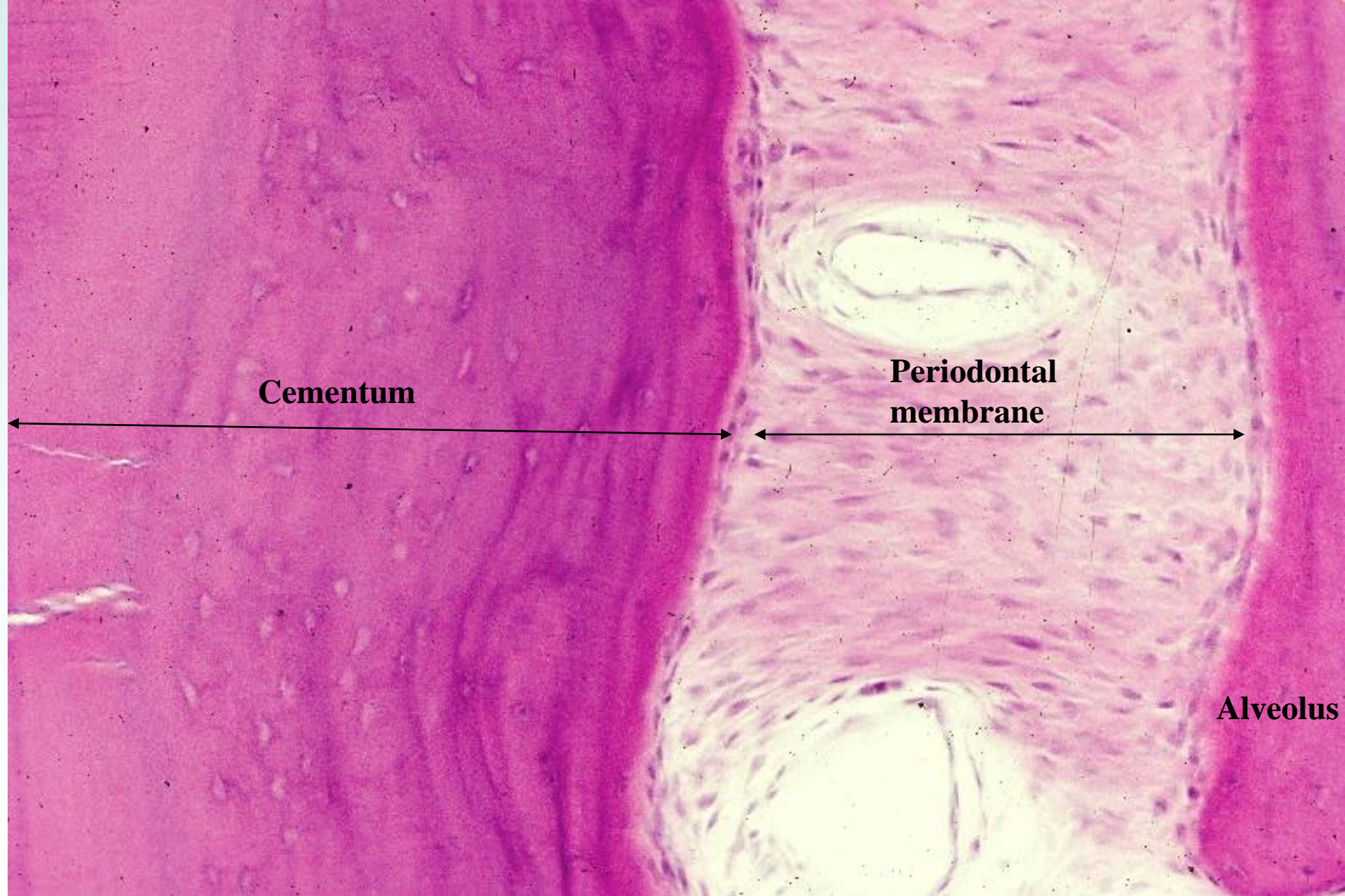
13-08 Roots of teeth in alveoli. Monkey, decalcified transverse section, H-E stain, x 4.0.



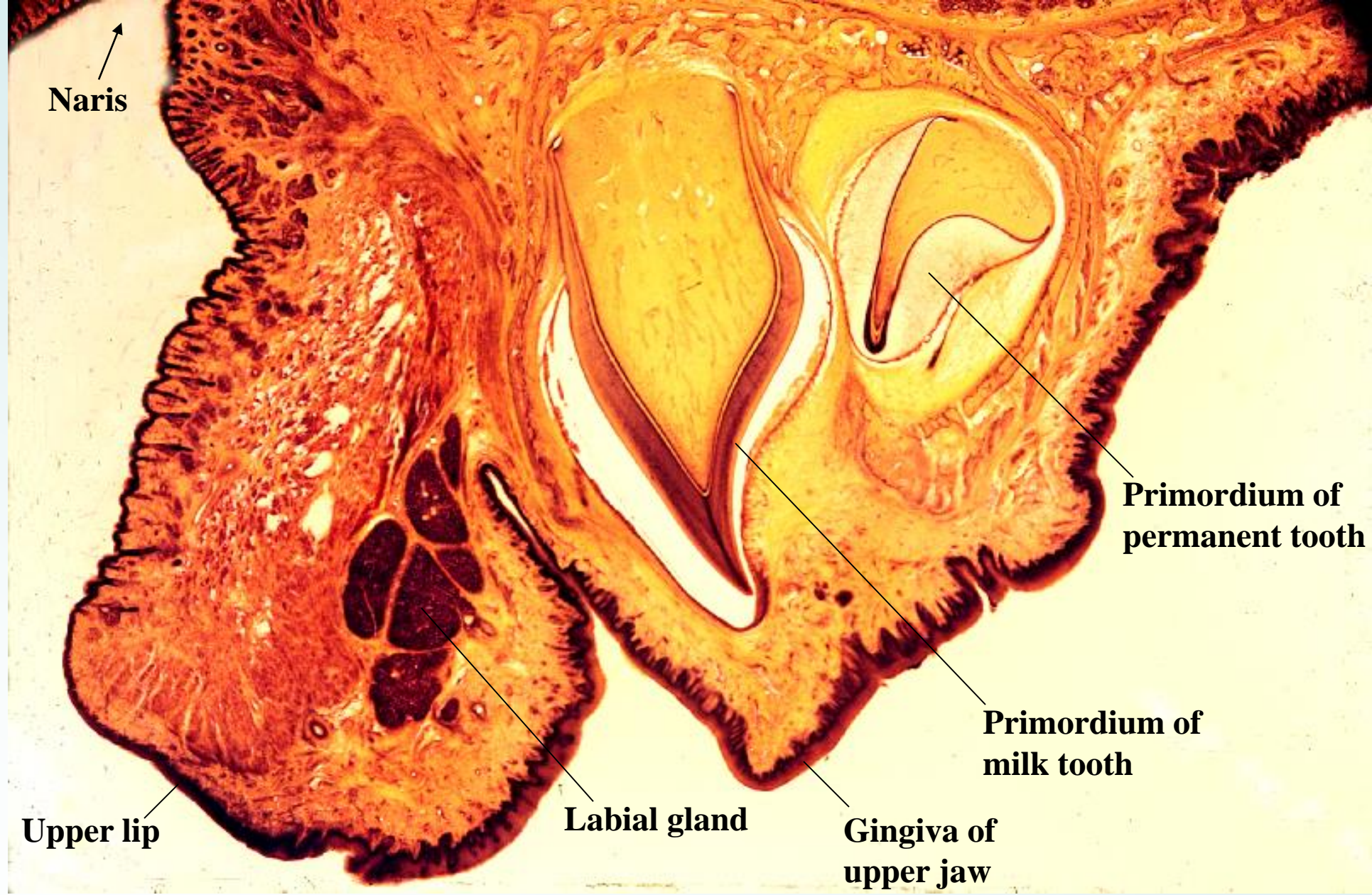
13-09 Root of a tooth in alveolus, 1. Monkey, decalcified transverse section, H-E stain, x 10.



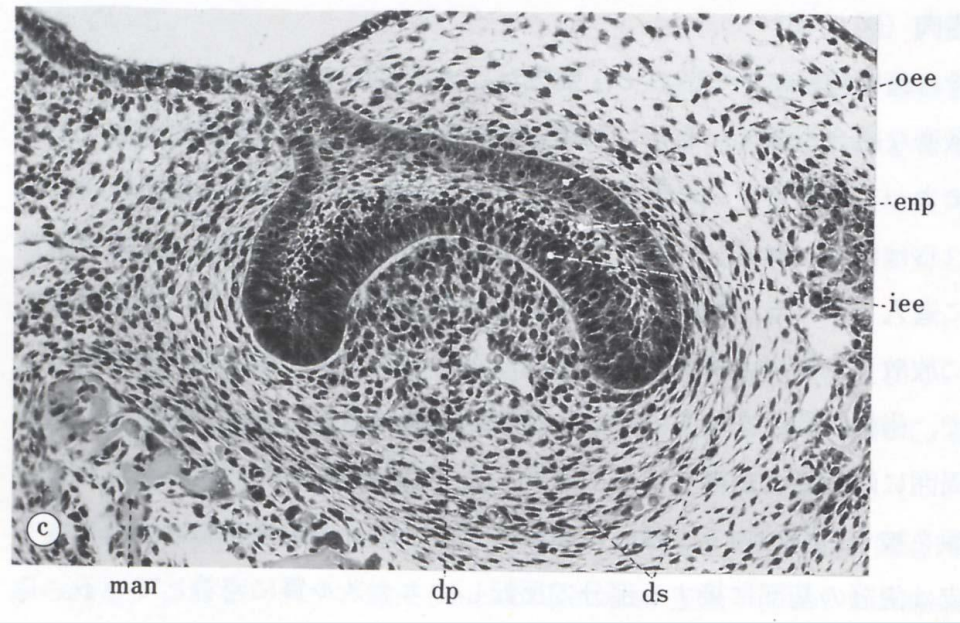
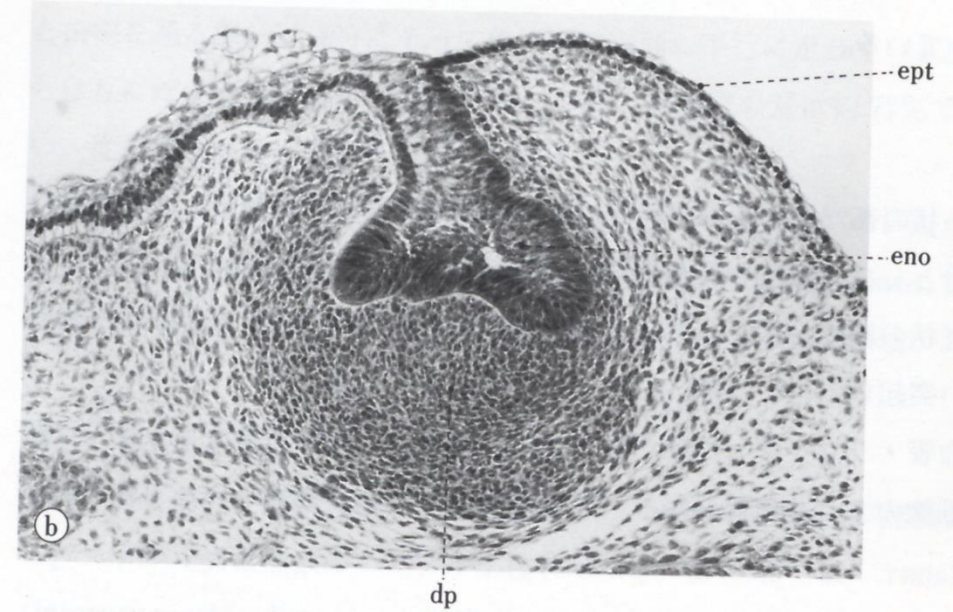
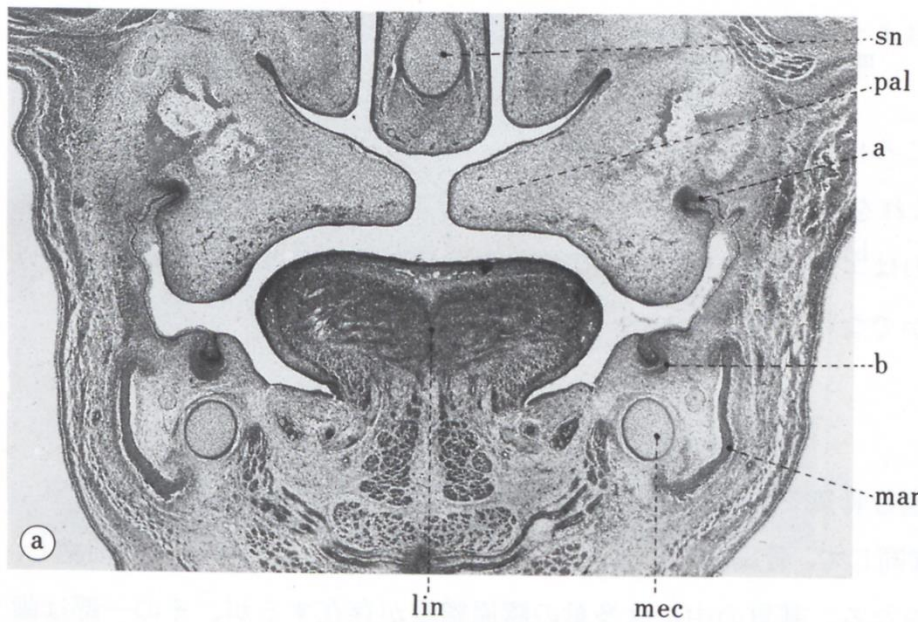
13-10 Root of a tooth in alveolus, 2. Monkey, decalcified transverse section, H-E stain, x 25.



13-11 Root of a tooth in alveolus, 3. Monkey, decalcified transverse section, H-E stain, x 64.



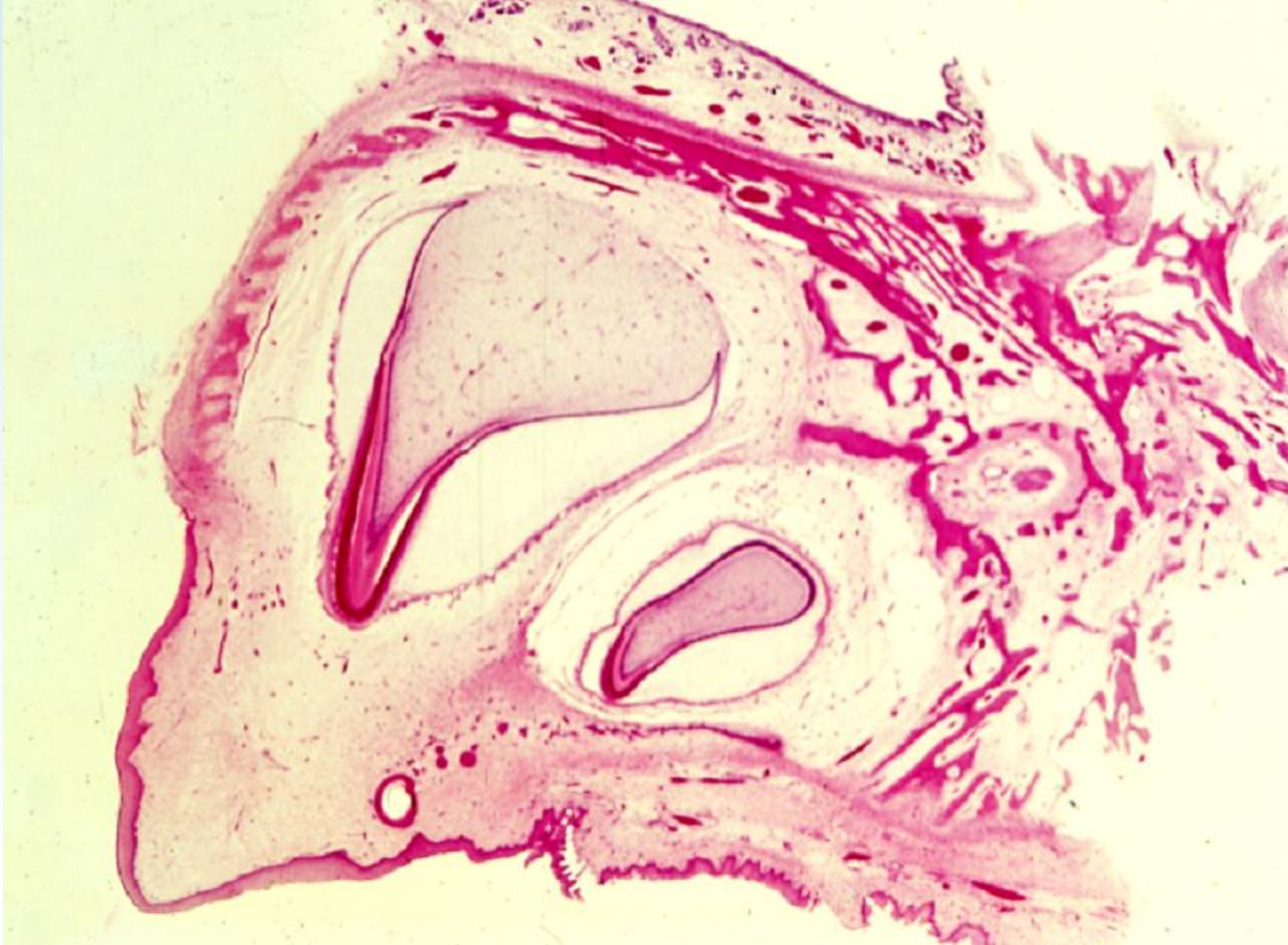
13-12 Sagittal section of upper jaw through naris. Human newborn, H-E stain, x 1.2.



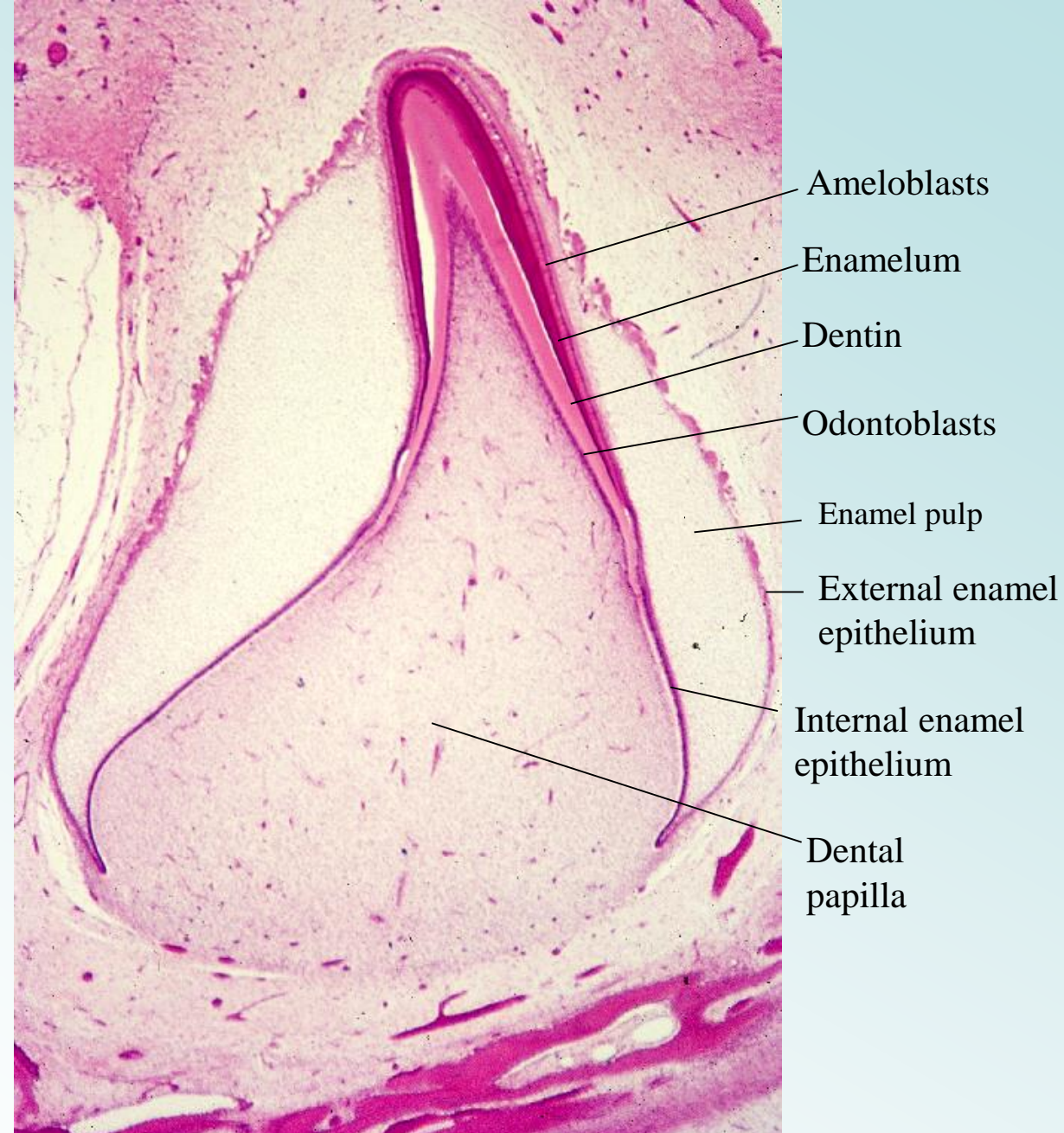
a: Frontal section of a 4-month-old human embryo.

b: Primordium of tooth of 4-month-old human embryo.

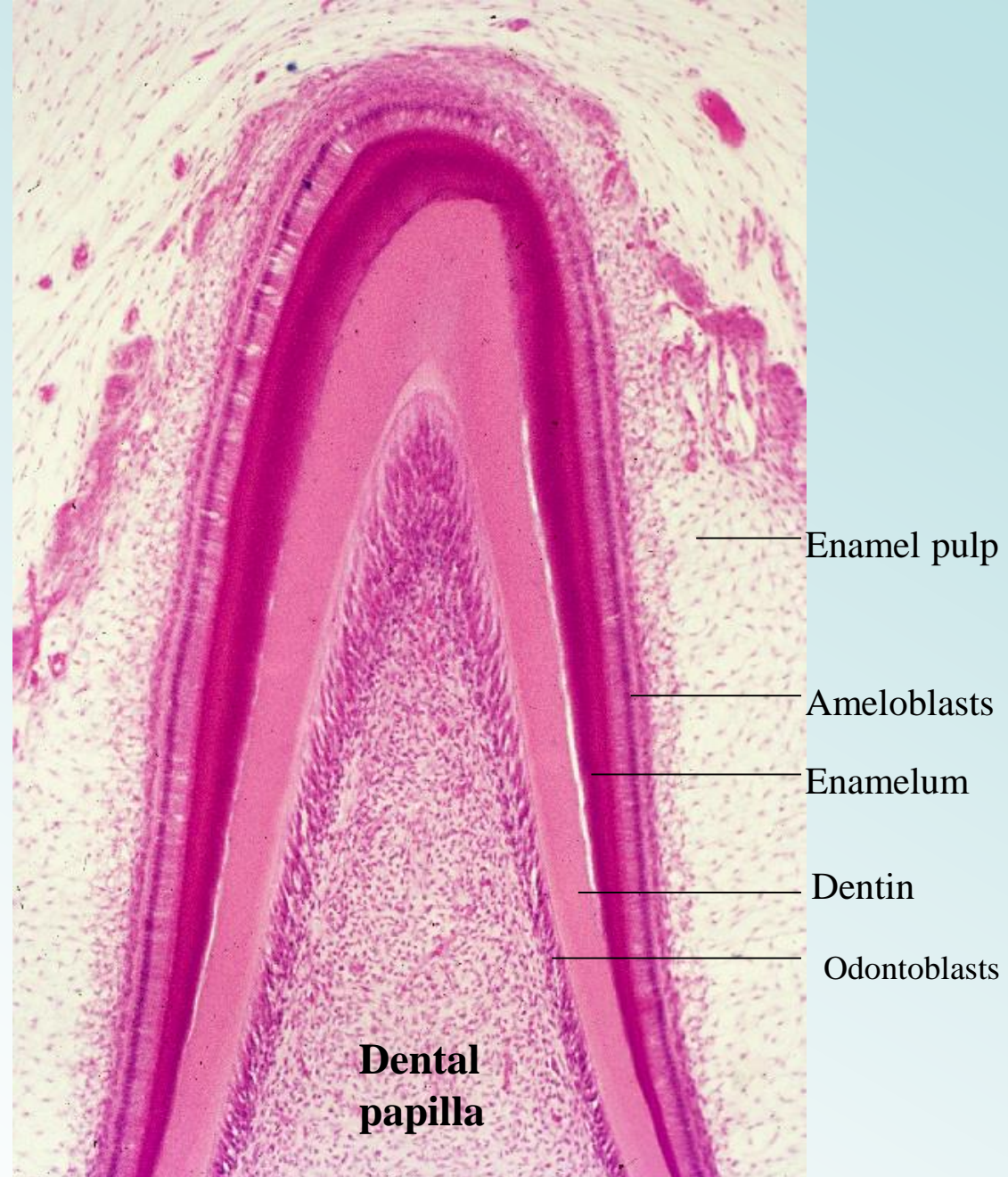
c: Primordium of tooth of 18-day-old rat embryo.



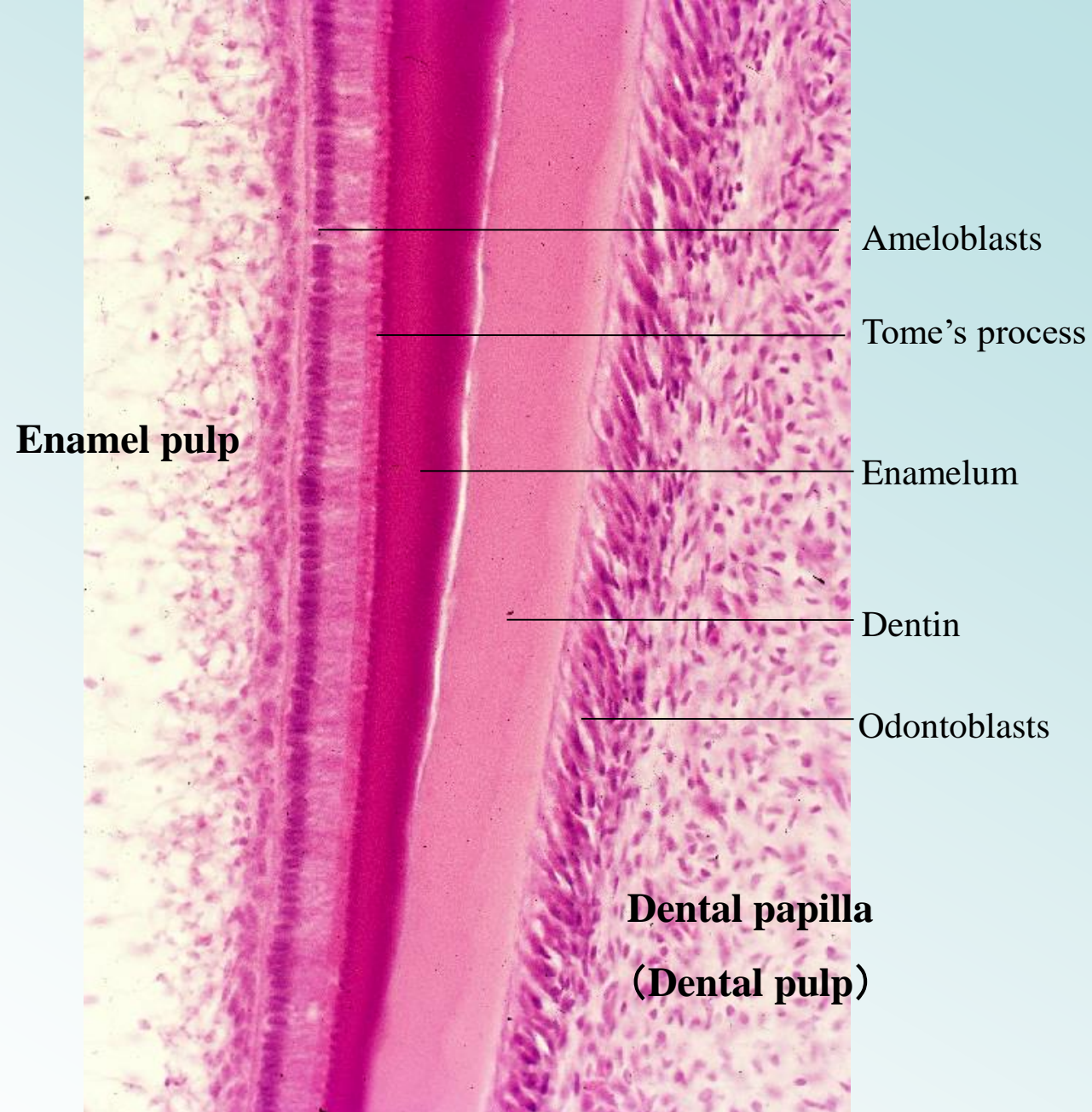
13-14 Development of tooth, 1. Human embryo, decalcified section, H-E stain, x 1.3.



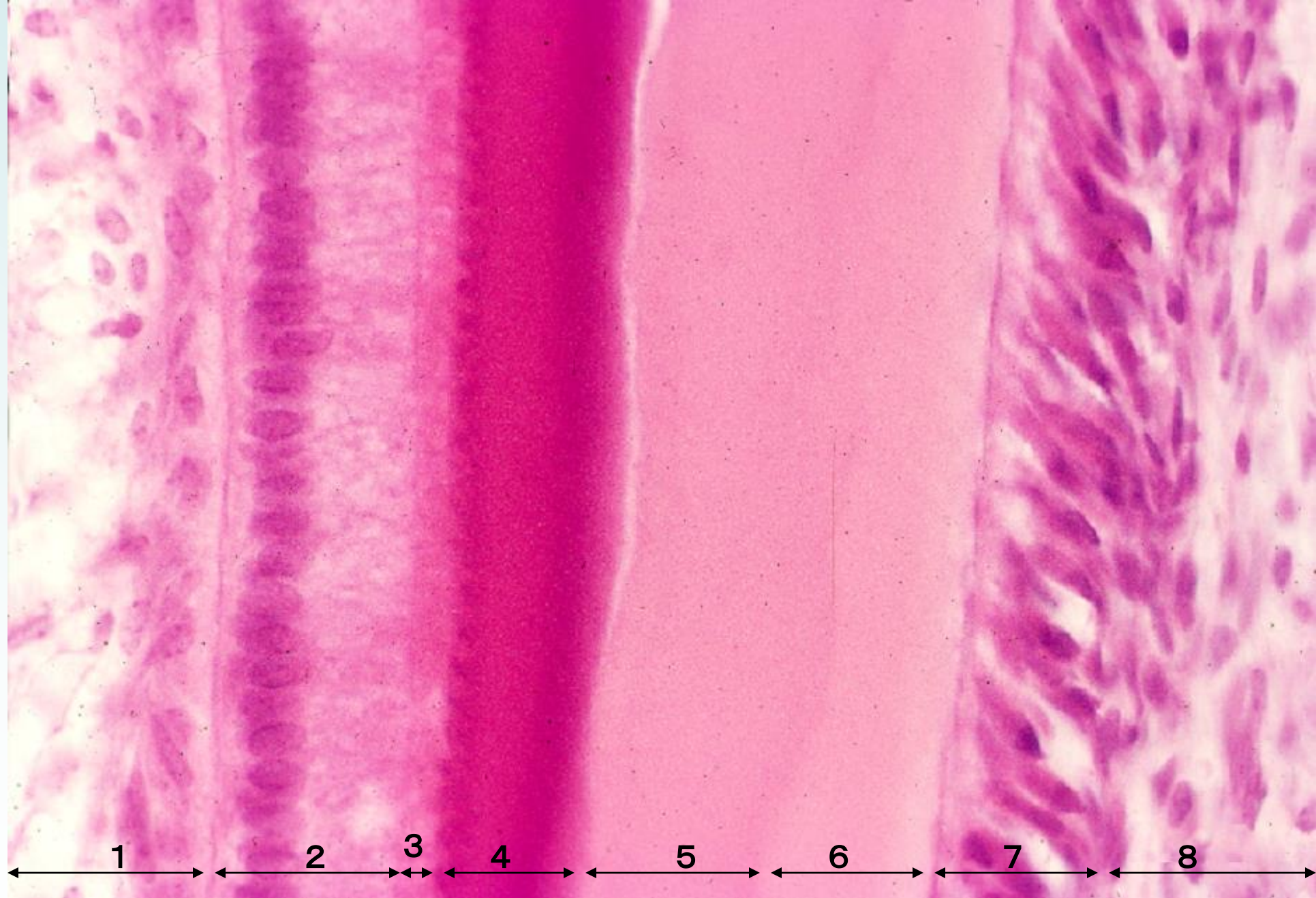
13-15 Development of tooth, 2. Human embryo, decalcified section, H-E stain, x 6.0.



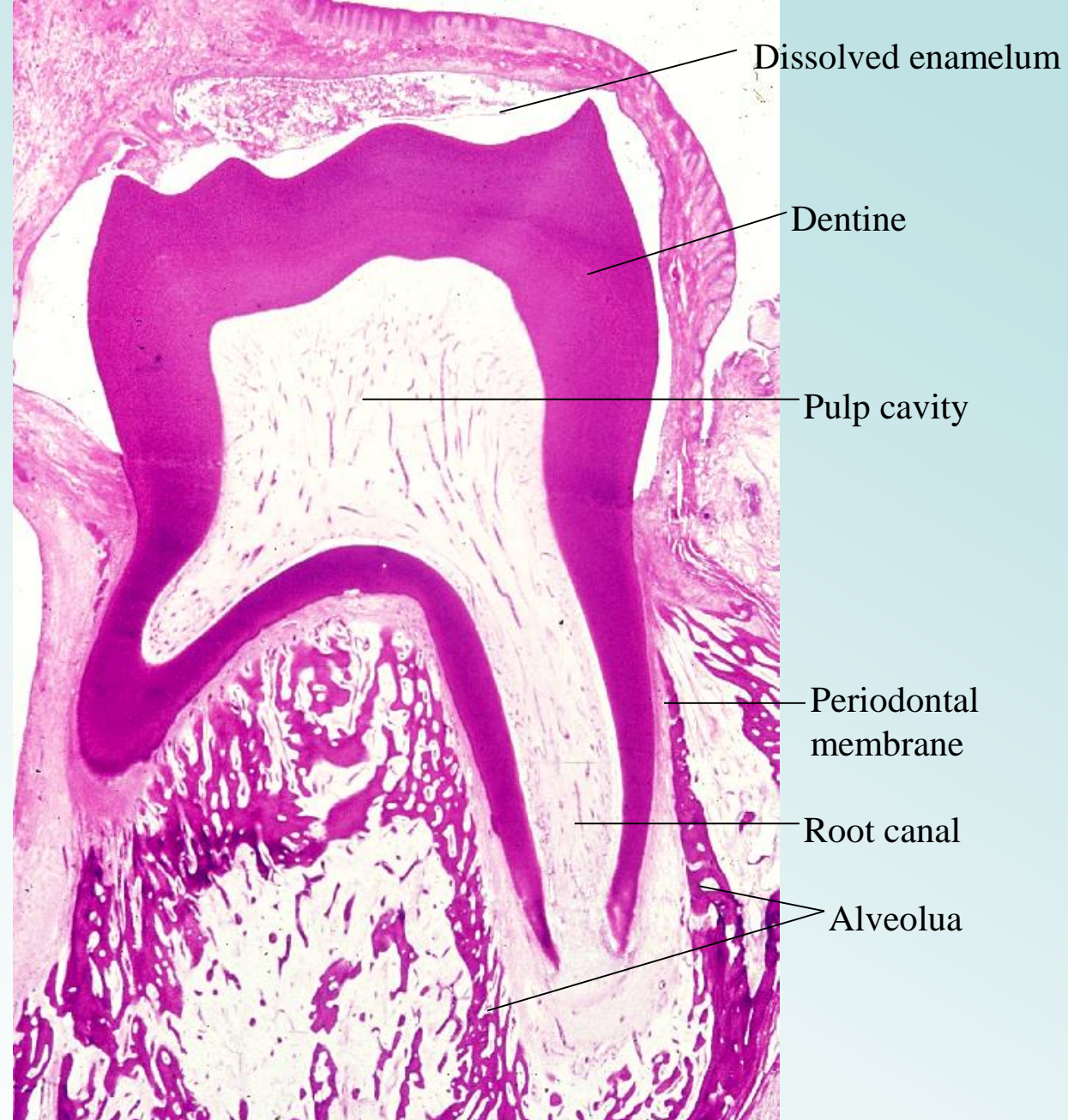
13-16 Development of tooth, 3. Human embryo, decalcified section, H-E stain, x 25.



13-17 Development of tooth, 4. Human embryo, decalcified section, H-E stain, x 64.



13-18 Development of tooth, 5. Human embryo, decalcified section, H-E stain, x 160.

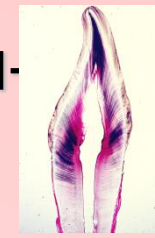


13-19 Major molar, shortly before eruption. Monkey, longitudinal section, H-E stain, x 1.6.

13-00 Digestive system 5 Teeth

- The teeth are the organs which are adapted for biting (the incisors) and for crushing and grinding (molars) the food.
- In man there are two sets of teeth, the deciduous teeth of childhood and the permanent teeth. Eruption of the former starts about the seventh month after birth and reach their full completion at 6 to 8 years of age. These teeth are shed between the sixth and the thirteenth year and are gradually replaced by the permanent teeth.
- All teeth consist of a crown projecting above the gingiva and one or tapering roots that occupy conforming sockets, alveoli, in the bone of the maxilla or mandible. The region of junction between the crown and the root is called the neck or cervix. The tooth has a central cavity, pulp cavity, which corresponds in its shape to the outer form of the tooth. This cavity continues downward into each root as a narrow root canal that communicates with the periodontal membrane at the tip of the root. The blood vessels, nerves and lymphatics enter and leave the tooth through the apical foramen.
- The hard portions of a tooth consist of three different tissues: dentin, enamel, and cementum. The bulk of the tooth is made up of dentin, which surrounds the pulp chamber. In the crown, dentin is covered by a layer of enamel, which is thinnest in the cervical region. On the root, dentin is covered by a thin layer of cementum which extends from the neck to the apical foramen.
- Teeth are studied in histological sections after removal of the hard inorganic constituents with acid, or in thin ground sections without decalcification.

13-01 Incisor, general view. Human, longitudinal ground section, carbol-fuchsin stain, x 1.3.



- This is to show a general view of a ground section through the axis of a human incisor, stained with carbol-fuchsin. The fundamental structures of an incisor are clearly shown. The axial portion of the dentin is occupied by the pulp cavity, which extends as root canal to the tip of the root. On the crown dentin is covered by the thick enamel, and on the root by the thin cementum. In the dentin there are innumerable radial striations from the pulp cavity toward the dentino-enamel junction, and also toward the dentino-cement junction. They are called dentinal tubules.

13-02 Crown of incisor. Human, longitudinal ground section, carbol-fuchs stain. x 4.0.



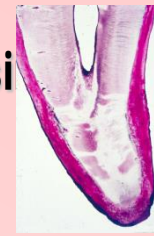
- The enamel consists of innumerable enamel rods or prisms of 4 to 5 μ m in diameter. They run parallel one another and perpendicular to the dentino-enamel junction. In the enamel there are another striations, starting from the dentino-enamel junction, crossing obliquely with the enamel rods, making large loops over the tip of the crown, and arriving at the dentino-enamel junction on the opposite side. They are called stripes of Retzius.

13-03 Neck of incisor. Human, longitudinal ground section, carbol-fuchin stain, x 4.0.



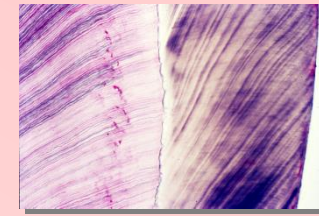
- At the neck the enamel ends and begins the cementum, which is first very thin and increases in thickness toward the apex. The cementum consists of bone substance.

13-04 Root of incisor. Human, longitudinal ground section, carbol-fuchsi stain, x 4.0.



- The cementum becomes thicker as nearing the tip of the root.

13-05 Enamel and dentin of incisor. Human, longitudinal ground section, carbol- fuchsin stain, x 25.



- This is a higher magnification of enamel and dentin of human incisor. In the middle runs the dentino-enamel junction from top downward and divides the figure into the dentin (left half) and enamel (right half).
- In the dentin there are innumerable parallel striations radiating from the pulp cavity toward the dentino-enamel junction. They are attributed to the presence of minute canals, dentinal tubules, whose diameter is 3 to 4 μm near the pulp cavity and about 1 μm near the dentino-enamel junction. Near this junction and parallel to it a row of small spots of irregular size and form is recognized. It is called the interglobular space which reflects the small areas of incomplete calcification. In this figure they appear as red stained spots.
- In the enamel two kinds of striations are observed. The one, fine and faint striations are countless striations, parallel to one another, start from dentino-enamel junction, run perpendicularly to this junction toward the free surface. They are thin enamel rods or prisms. The other, starting from the dentino-enamel junction, crossing obliquely with the enamel rods, making large loops over the tip of the crown, and arriving at the dentino-enamel junction on the opposite side. They are called stripes of Retzius and very conspicuous in this figure.

13-06 Dentin and cementum of incisor. Human, longitudinal ground section carbol- fuchsin stain, x 25.



- At about three fifth from the left edge runs the junction of dentin (left) and cemen- tum (right) from top downward. In the dentin, as figure 13-06, there are innumerable parallel striations of dentinal tubules, perpendicular to this junction. Immediately under the junction there is a layer of small black dots; This is called the granular layer of Tomes.
- The cementum, being identical to the bone, numerous cementocytes providing with many fine processes are scattered. They appear as small black structures in the deep red stained ground substance.

13-07 Molar in alveolus. Monkey, decalcified longitudinal section, H-E stain, x 1.5.



- This is a decalcified longitudinal section of a molar with alveolus. The enamel was entirely dissolved and disappeared. Two roots fit in the axial portion of each alveolus and are firmly connected with alveolus by the periodontal membrane, which serves as periosteum to the alveolar bone. The periodontal membrane consists, in part, of thick collagen fiber bundles, Sharpey's fibers, that run from the alveolar wall into the cementum. The orientation of the fibers varies at different levels in the alveolus. At the neck, fibers are horizontal and especially prominent and firmly attached to the cementum. Lower to this level collagen fiber bundles connect obliquely between the higher portion of the alveolar wall and the deeper portion of the root. The cementum appears in this figure as thin layer on the surface of the root, stained deep violet.

13-08 Roots of teeth in alveoli. Monkey, decalcified transverse section, E stain, x 4.0.



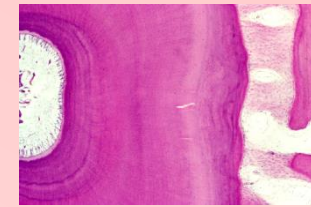
- In this figure two roots and their alveoli are seen. The lower edge is the epithelium of the gingival mucosa, followed by the connective tissue of the submucosa. In the periodontal membrane, radial arrangement of the collagen fiber bundles connecting the root and the alveolar wall is quite conspicuous. The right root and its alveolus are shown at higher magnification in 13-09.

13-09 Root of a tooth in alveolus, 1. Monkey, decalcified transverse section, H-E stain, x 10.



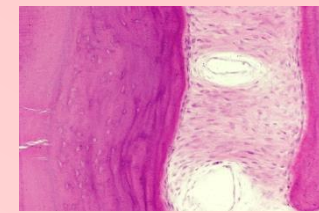
- The axial portion of the root is occupied by the pulp cavity (root canal), which is filled by very loose connective tissue, blood vessels, lymphatics and nerves. This cavity is lined by the tall columnar cells, odontoblasts, each of that sends a long protoplasmic process into the dentinal tubule. In the dentine innumerable dentinal tubules radiate from the pulp cavity toward the surface, which is covered by the cementum. In this figure the cementum appears as a thin layer stained deep violet. The cementum and alveolar wall are connected by the periodontal membrane consisting of numerous thick collagen fiber bundles that show the radial arrangement. Spaces between these thick bundles are filled by very loose connective tissue and thin blood vessels. The inner surface of the alveolus is covered by the periodontal membrane which serves as periosteum.

13-10 Root of a tooth in alveolus, 2. Monkey, decalcified transverse section, H-E stain, x 25.



- Higher magnification of 13-09. In the pulp cavity very loose connective tissue containing blood vessels and nerves is seen. The inner surface of the cavity is lined by a layer of tall columnar cells. They are the odontoblasts that send the protoplasmic processes into the dentinal tubules. The thick collagen fiber bundles of periodontal membrane connect the cementum firmly with the wall of the alveolus. Spaces between these bundles are filled by very loose connective tissue

13-11 Root of a tooth in alveolus, 3. Monkey, decalcified transverse section, H-E stain, x 64.



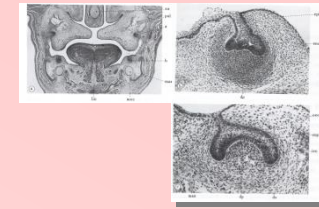
- Higher magnification of 13-10. This figure is to show the cementum, periodontal membrane and alveolus. In the cementum numerous lacunae of odontoblasts are seen. The periodontal membrane consists of thick collagen fiber bundles which connect very firmly the cementum with the alveolus. Among these bundles penetrate blood vessels with loose connective tissue at regular intervals.

13-12 Sagittal section of upper jaw through naris. Human newborn, H-E stain, x 1.2.



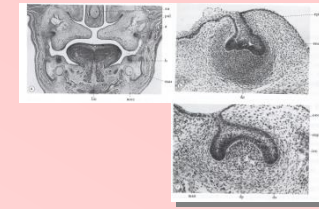
- At upper left corner is the naris; following downward is the upper lip. Rightward to it is the massive upper gingiva which contains the primordium of a milk tooth (left) and that of a permanent tooth. The primordium of the milk tooth is large and its enamel, already formed, was dissolved. Its root is still not formed. The primordium of the permanent tooth is small and shows the early developmental stage.

13-13 Development of tooth. (1/3)



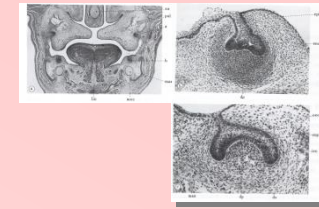
- a: frontal section of a 4-month-old human embryo.
- b: primordium of a tooth of a 4-month-old human embryo.
- c: primordium of a tooth of a 18-day-old rat embryo.
- The enamel is derived from the ectodermal epithelium lining the oral cavity, whereas other components of tooth are the derivatives of the mesenchyme.
- In the embryos at about the end of 6th. week (about 10mm C-R length), along the inner edge of the upper and lower lips appear two parallel concentric thickening lines of the ectodermal epithelium; the outer divides in future the lip from the gingiva and is called the labio-gingival lamina. The inner, forming in future the enamel, is called dental lamina. The ectodermal cells multiply actively, enter into the mesenchyme perpendicularly and form a plate of horseshoe form opening backward. At about the end of the 8th week at 10 sites of the labial surface of this plate develop the spherical cell lumps with a handle; they are called enamel buds. Around these buds mesenchymal cells come together with blood vessels.
- The enamel buds grow rapidly and cells of the distal portion invaginate apicalward, forming the double walled cap-shaped structures; they are called the enamel organs. The invaginated inner cells are arranged as simple columnar epithelium and called “inner enamel epithelium” or ameloblasts (see in figure c), which later produce the enamel. The cells of proximal (outer) side become simple cuboidal epithelium and are named “outer enamel epithelium (oee in figure b). The cells locating in the space between the outer and inner enamel epithelia are loosely packed, with long processes joined by desmosomes to form a stellate reticulum, and are called, as a whole, enamel pulp (enp in figure c).

13-13 Development of tooth. (2/3)



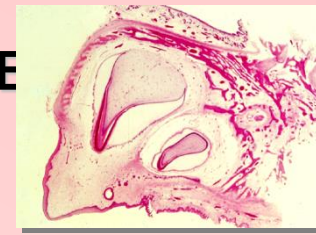
- The mesenchymal cells in the hollow limited by the inner enamel epithelium multiply actively and fill this space densely. These are called dental papilla (dp in figures b and c). The mesenchymal cells underlying the inner enamel epithelium become transformed into tall columnar cells, with their bases toward the interior of the papilla, and are called odontoblasts, which later produce the dentin.
- The enamel organ and dental papilla are together enclosed by the dense mesenchymal tissue, called dental sac (ds in figure c).
- The lower edge of the cap-like enamel organ, where the outer enamel (dental) epithelium is continuous with the inner enamel (dental) epithelium, will later mark the lower limit of the enamel at the neck of the tooth. As the enamel organ enlarges, it becomes bell-shaped and its under surface gradually takes on the contour of the crown of the tooth.
- In fetuses of about 20 weeks gestation, odontoblasts begin to produce procollagen and release it from their apical portion into the space between the ameloblasts and odontoblasts. This collagenous substance is named predentin, which is later calcified and becomes into dentin. Dentin first appears thus as a thin layer between the odontoblasts and ameloblasts. Calcification follows soon after deposition of new dentin, but there is always a thin uncalcified layer adjacent to the odontoblasts. As the odontoblasts recede, with the deposition of more dentin, their lengthening apical processes remain in the tubules within the dentin. The predentin around the apices of the odontoblasts is a soft fibrillar zone rich in collagen. It is traversed by fibers from deeper in the papilla, called Korff's fibers. These spread out fan wise within the matrix of the dentin.

13-13 Development of tooth. (3/3)



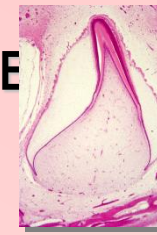
- Soon after the first appearance of calcified dentin around the dental papilla, the ameloblasts begin to deposit layer after layer of enamel on its surface facing the dentin, extracellularly. As the mass of enamel increases ameloblasts recedes, and thus the distance between ameloblasts and odontoblasts increases. The ameloblasts are tall columnar in shape and arranged orderly perpendicular to the enamel. They have elongated nucleus in the basal cytoplasm. Distal to a conspicuous terminal web in the apical cytoplasm there is a broad apical process, Tome's process, which continues into the calcified enamel matrix.
- Development of the root of the tooth begins shortly before the eruption of the crown of the tooth. Continued downward growth of the inner and outer dental epithelium from the lower edge of the enamel organ gives rise to a bilayered fold, called sheath of Hertwig, around a lengthening papilla cavity. The cells of this sheath induce neighboring papilla cells to differentiate into odontoblasts. These align themselves with the layer of differentiated odontoblasts in the cervical region of the tooth and begin to secrete a layer of predentin that is continuous with that already present in the crown. This is soon followed by the secretion of dentin by these odontoblasts, initiating the formation of the root of the tooth. Continuing downward growth of sheath of Hertwig and its induction of more odontoblasts results in progressive elongation of the root until it reaches its definitive length. The sheath of Hertwig then disappears. After its disintegration, cells of the surrounding connective tissue sheath differentiate into cementoblasts and deposit an acellular layer of cement on the root. Further deposition of cement entraps bundles of collagen fibers that are incorporated, at their other end, in trabeculae of the alveolar bone. These fibers, and those that replace them in the continual turnover of the tissue, ultimately form the periodontal ligament that anchors the tooth to its bony socket.
- In eruption of the tooth, the crown is moved through the overlying cellular remnants of the enamel organ which seem to disintegrate in its path. It then passes through the gingiva to emerge in the oral cavity.

13-14 Development of tooth, 1. Human embryo, decalcified section, H-E stain, x 1.3.



- This is a sagittal section of the upper jaw of a human embryo containing primordia of milk (upper left) and permanent (lower right) teeth. In the primordium of the milk tooth development of enamel as well as dentin already took place at the top of the inner enamel epithelium. The lower edge of the cup-like enamel organ, where the outer enamel epithelium is continuous with the inner enamel epithelium, will later mark the lower limit of the enamel at the neck of the tooth. As the enamel organ enlarges, it becomes bell-shaped and its under surface gradually takes on the contour of the crown of the tooth. Higher magnification figures are shown in 13-15 ~ 13-18.

13–15 Development of tooth, 2. Human embryo, decalcified section, H-E stain, x 6.0.



- This is a primordium of a milk tooth. At the top, where the development of the enamel and dentin takes place, the ameloblasts and the odontoblasts are tightly opposed with their apical end.
- The odontoblasts release the procollagen from their apical portion into the space between the ameloblasts and odontoblasts. Calcification follows soon after deposition of new dentin, but there is always a thin uncalcified layer adjacent to the odontoblasts. As the odontoblasts recede, with the deposition of more dentin, their lengthening apical processes remain in the tubules within the dentin. The predentin around the apices of the odontoblasts is a soft fibrillar zone rich in collagen.
- Soon after the first appearance of calcified dentin around the papilla, the ameloblasts begin to deposit layer after layer of enamel on its apical surface, facing the dentin. The ameloblasts are tall columnar in shape and have elongated nucleus in the basal cytoplasm. Distal to a conspicuous terminal web in the apical cytoplasm there is a broad apical process, Tome's process, which continues into the calcified enamel matrix.

13-16 Development of tooth, 3. Human embryo, decalcified section, H-E stain, x 25.



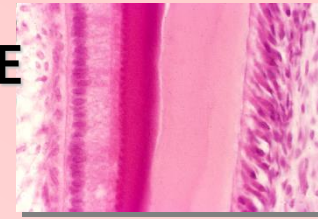
- This is a higher magnification of the top region of 13-15, where the deposition of dentin and enamel takes place. At center there is the dental papilla (dental pulp), triangular in shape. On its verge long spindle shaped cells are arranged very densely; they are odontoblasts and surrounded by dentin, stained deep pink. Next to it is a layer of enamel, stained dark reddish-violet, that are surrounded by the inner enamel epithelium, being the simple tall columnar epithelium. The outermost layer is the enamel pulp consisting of the ectodermal reticulum.

13-17 Development of tooth, 4. Human embryo, decalcified section, H-E stain, x 64.



- This is a higher magnification of a portion of 13-16, showing the process of the dentin and enamel formation in detail. Following structures are lined up from left to right.
 - ①. Enamel pulp consisting of the ectodermal reticulum.
 - ②. Ameloblasts, orderly arranged simple tall columnar epithelium; nuclei of the epithelial cells locate in the basal cytoplasm.
 - ③. On the apical portion of the ameloblasts there is a thin layer of Tome's process.
 - ④. The enamel, stained dark reddish-violet.
 - ⑤. The dentin, stained deep pink. The dentin is opposite with the enamel directly.
 - ⑥. Between the dentin and odontoblasts there is a thin layer of predentin, stained faint pink.
 - ⑦. Odontoblasts. They are long spindle shaped cells, densely arranged parallel with one another, but they are not epithelium. Their arrangement is not perpendicular to the basal line of the predentin.
 - ⑧. Dental pulp consisting of mesenchymal reticular tissue.

13-18 Development of tooth, 5. Human embryo, decalcified section, H-E stain, x 160.



- The structures concerning the formation of the dentin as well as the enamel are seen more precisely. ①. Enamel pulp. ②. Ameloblasts. ③. Tome's process. ④. Enamel. ⑤. Dentin. ⑥. Predentin. ⑦. Odontoblasts. ⑧. Dental pulp.

13-19 Major molar, shortly before eruption. Monkey, longitudinal section, H-E stain, x 1.6.



- This is a decalcified longitudinal section of a molar, shortly before eruption. The crown consists of enamel and dentin; but enamel is entirely dissolved, leaving some remnants. Dentin is thick and well formed and its form reflects the surface form of enamel. Dentin contains a wide dental cavity within it, which continues into the two root cavities. The dental cavity and root cavities are filled by very loose connective tissue containing numerous blood vessels, i.e. dental pulp. The two roots fit each into the alveolus, tightly connected by the periodontium.
- The development of the root begins shortly before the eruption of the tooth, continues after the crown has emerged from the mucous membrane, and is not completed until much later. The epithelial sheath disappears when the root is completely developed.