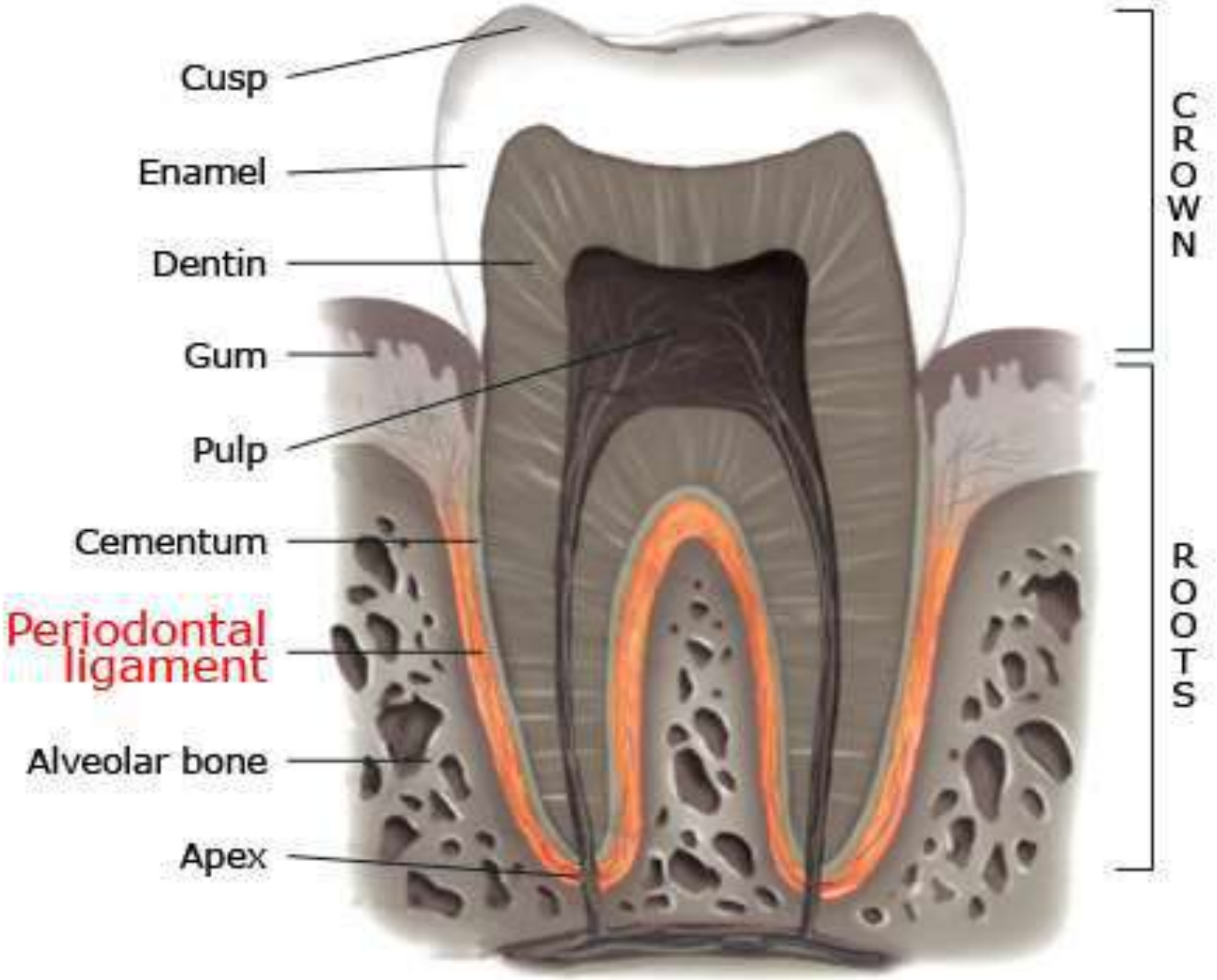

Cusp
Enamel
Dentin
Gum
Pulp
Cementum
Periodontal ligament
Alveolar bone
Apex
CROWN
ROOTS

PERIODONTAL LIGAMENT

DEPARTMENT OF PERIODONTOLOGY

PRESENTED BY :
DR. RAKESH MUTHA

INDEX

INTRODUCTION

PERIODONTIUM:

It is defined as tissues that invest or help support the tooth, consisting of *cementum*, the *periodontal ligament*, the *bone* lining the alveolus (socket) and the part of gingiva facing the tooth.

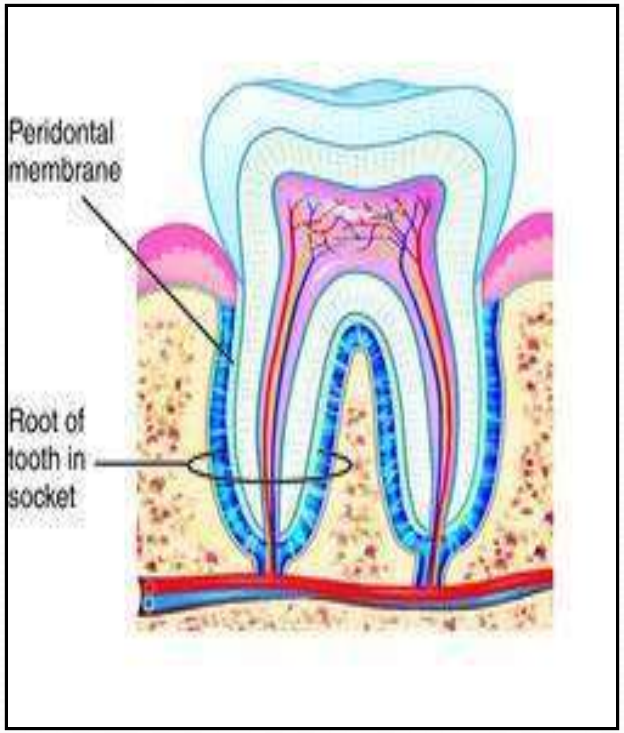
INTRODUCTION

PERIODONTAL LIGAMENT (PDL):

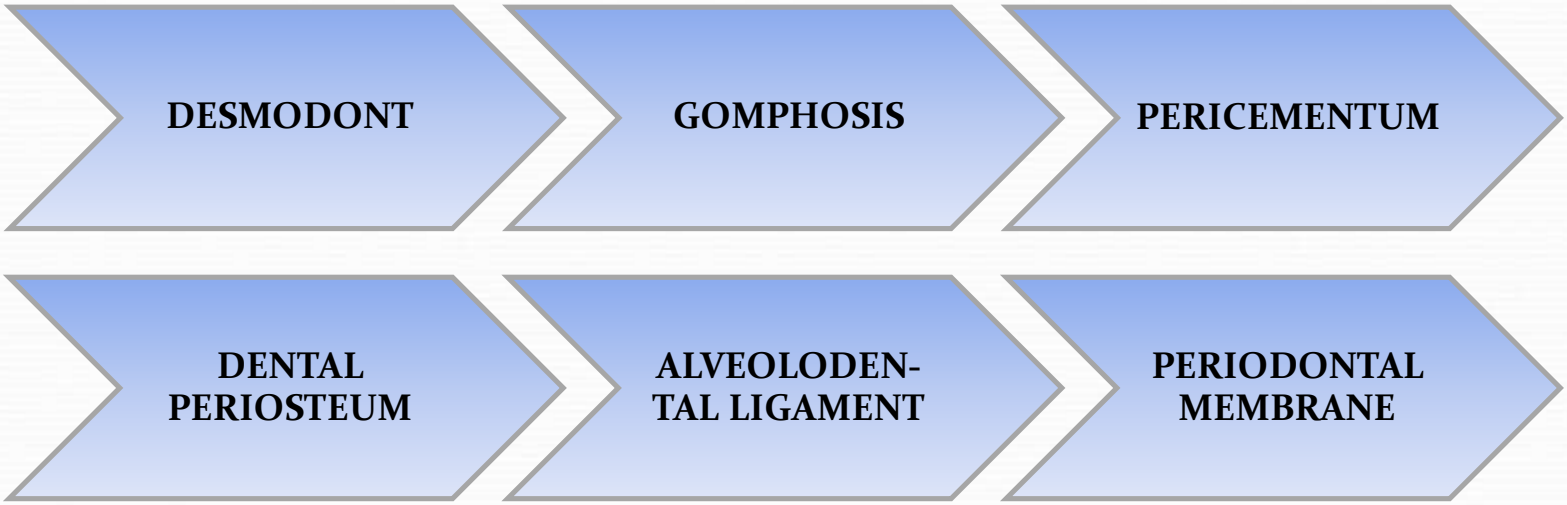
PDL is soft, richly vascular and cellular connective tissue, which surrounds the roots of the teeth and joins the root cementum with the alveolar bone of the jaws.

- The supporting tissues of tooth forms a specialized fibrous joint known as GOMPHOSIS.

- The investing tissues represent an adaptation of oral mucosa as the tooth erupts through it.

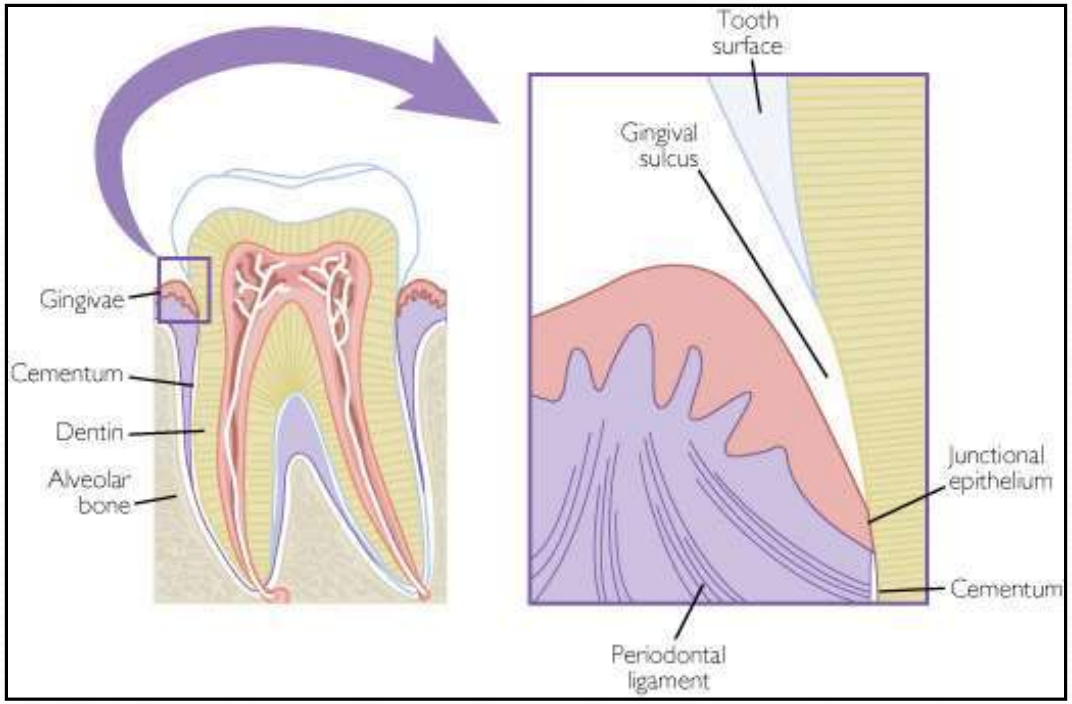


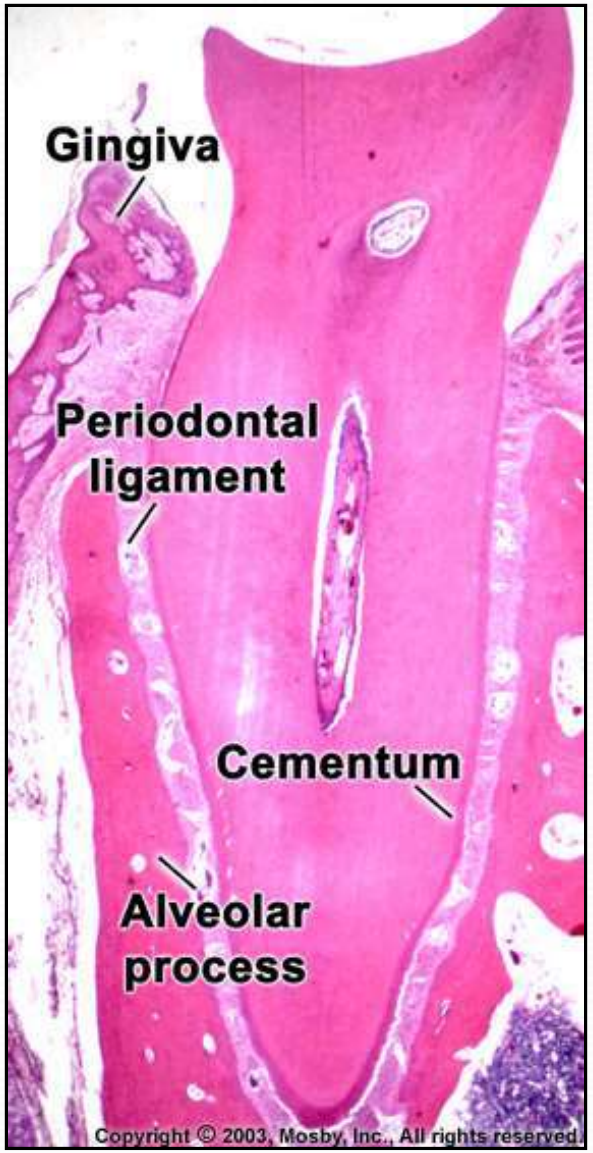
- Over the years, the periodontal ligament has been described by a number of terms:



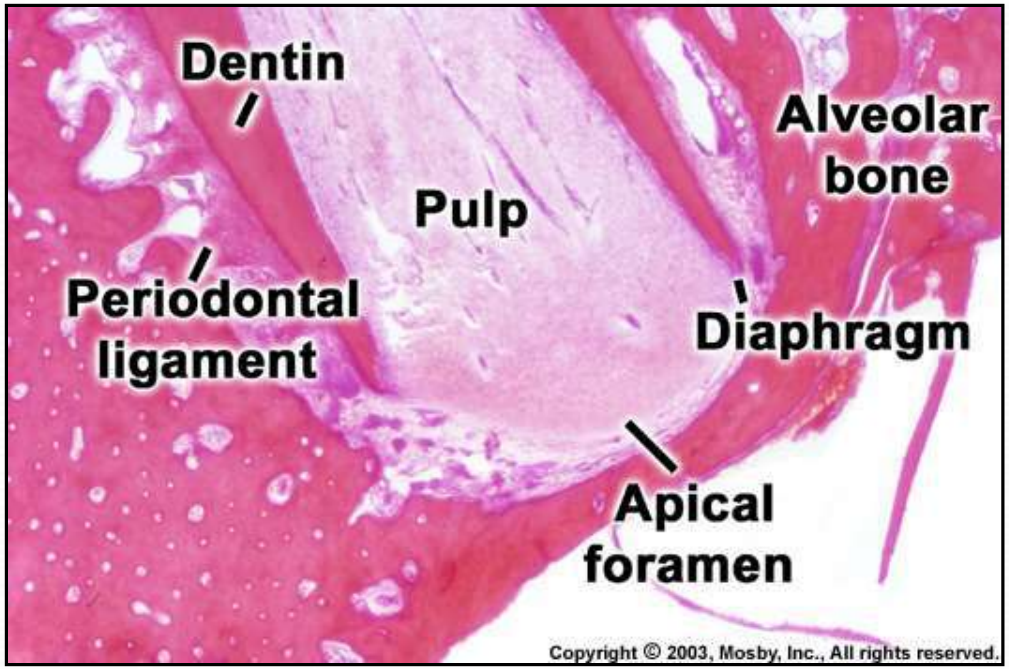
- "Periodontal membrane" and "periodontal ligament" are the terms most commonly used.

- In the coronal region, the periodontal ligament is continuous with the lamina propria of the gingiva.

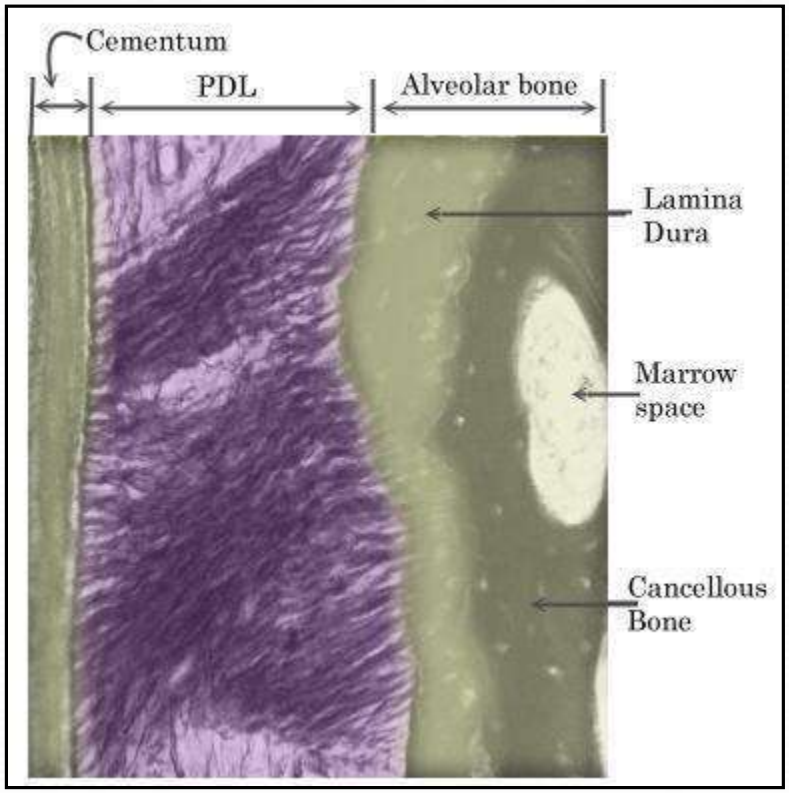




- At the apical foramen it is continuous with the dental pulp.



- Communicates through vascular channels (Volkman's canal) in the alveolar bone proper with the marrow spaces of the alveolar bone.



FEATURES OF PDL …

- The Normal width is approximately 0.1 to 0.25mm.
  - In case of Mastication : 0.2 to 0.25 mm
  - In case of increased function : 0.28 to 0.35 mm
  - In case of decreased function : 0.1 to 0.15 mm.

  - Space is narrower in permanent teeth than decidous teeth.

Age	Avg Alv. Crest	Avg Mid root	Avg Apex	Avg
11 – 16 years (83 teeth from 4 jaws)	0.23mm	0.17mm	0.24mm	0.21mm
32 – 50 years (36 teeth from 5 jaws)	0.20mm	0.14mm	0.19mm	0.18mm
51 – 67 years (35 teeth from 5 jaws)	0.17mm	0.12mm	0.16mm	0.15mm
24 years (18 teeth from 1 jaw)	0.16mm	0.09mm	0.15mm	0.13mm

Thickness of the periodontal ligament of 172 teeth from 15 twin jaws

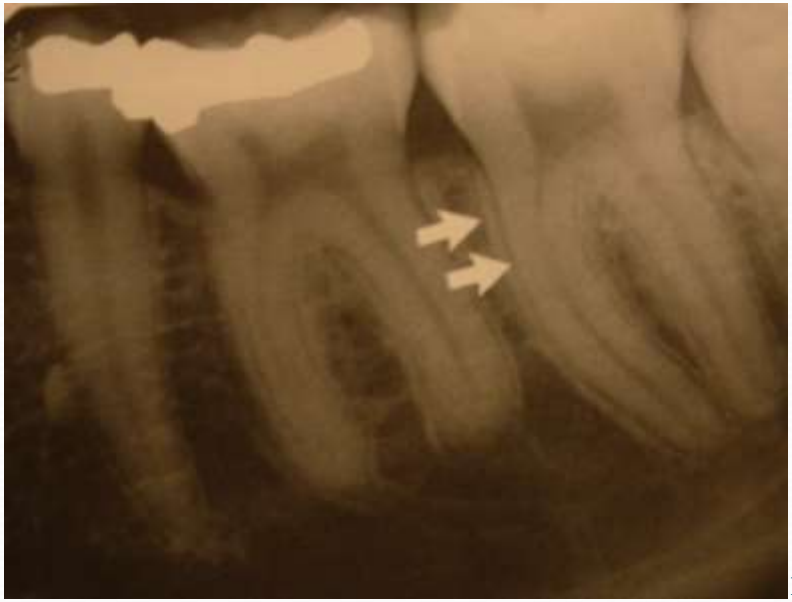
- Narrowest at the mid root level.

- Shape – hourglass.

Periodontal ligament space –

It is the narrow space between the tooth and the alveolar bone.

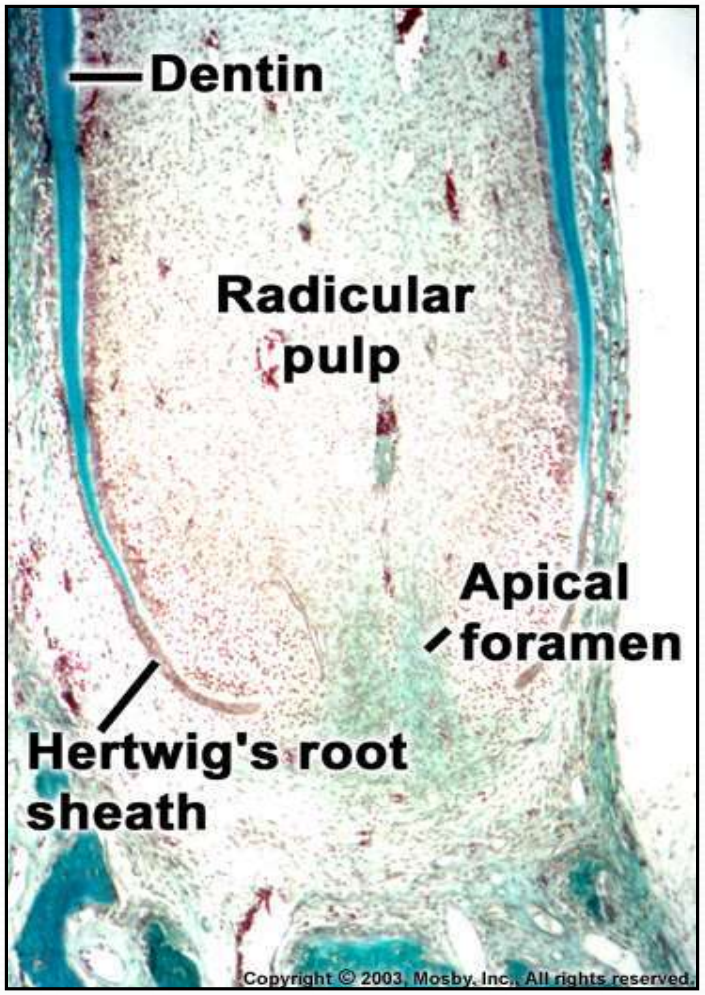
It is seen radiographically as a radiolucent line surrounding the bone.



DEVELOPMENT

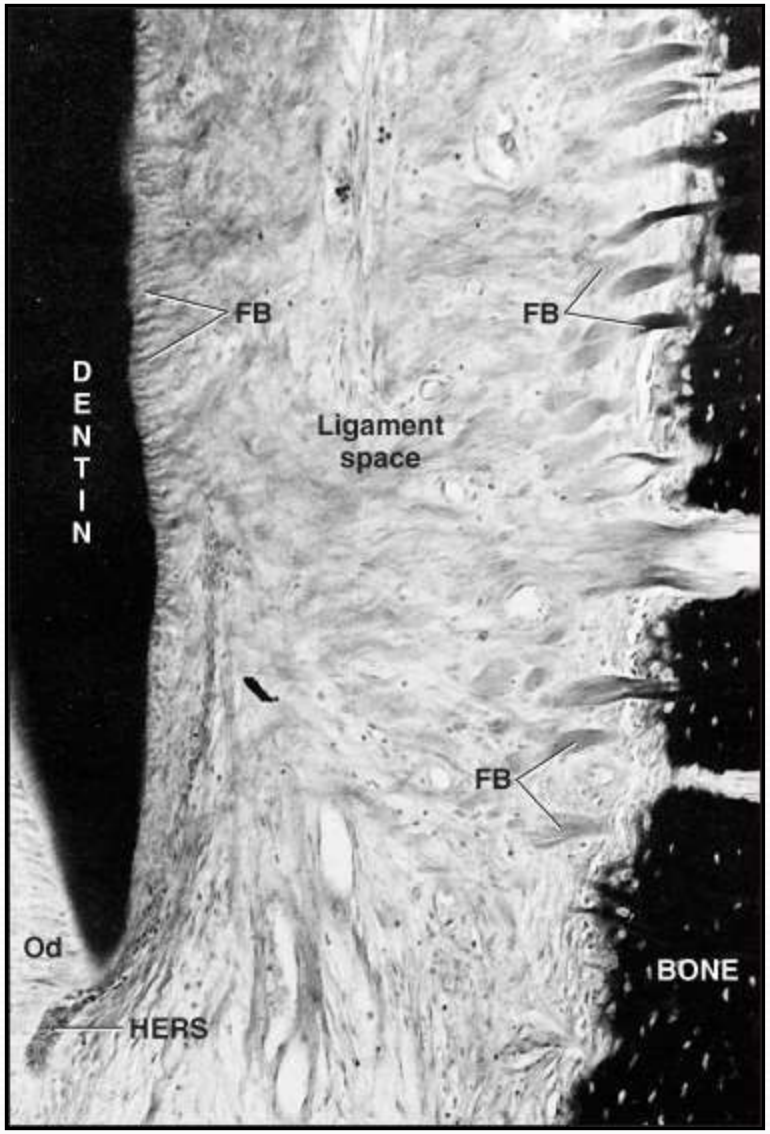
- Root formation begins with the appearance of the epithelial root sheath **(Hertwig 1874).**

- Following the onset of root formation, changes become apparent within the dental follicle that are associated with the development of principal fiber groups of the periodontal ligament.



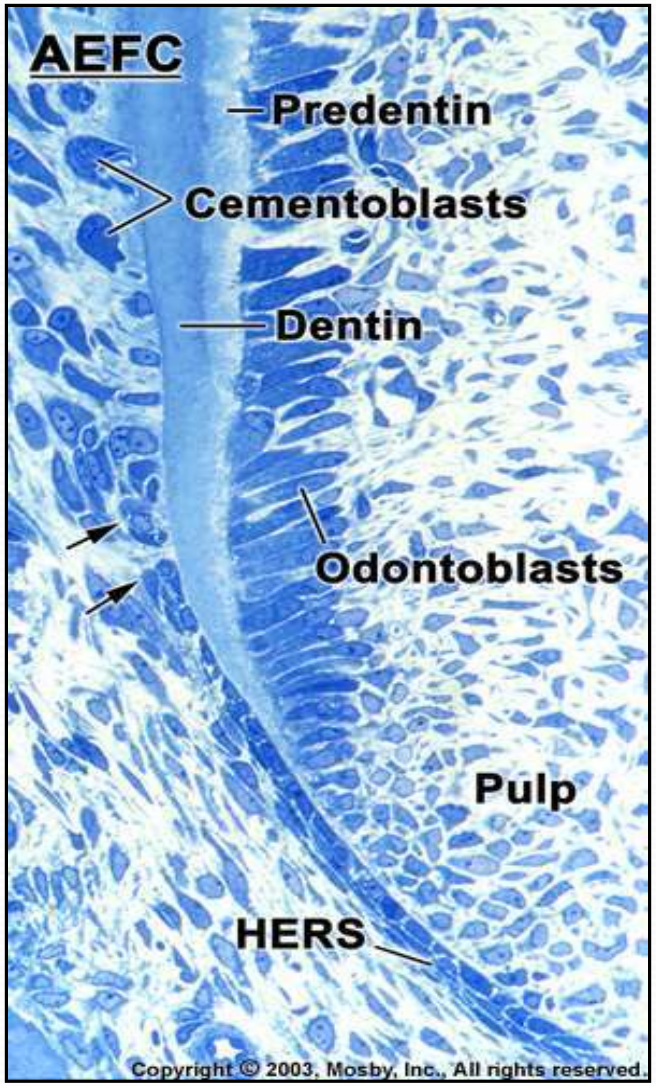
- At the commencement of ligament formation, the ligament space consists of unorganized connective tissue with short fiber bundles extending into it from the bone and cemental surfaces.

- Next, the ligament mesenchymal cells begin to secrete collagen (mostly type I collagen).

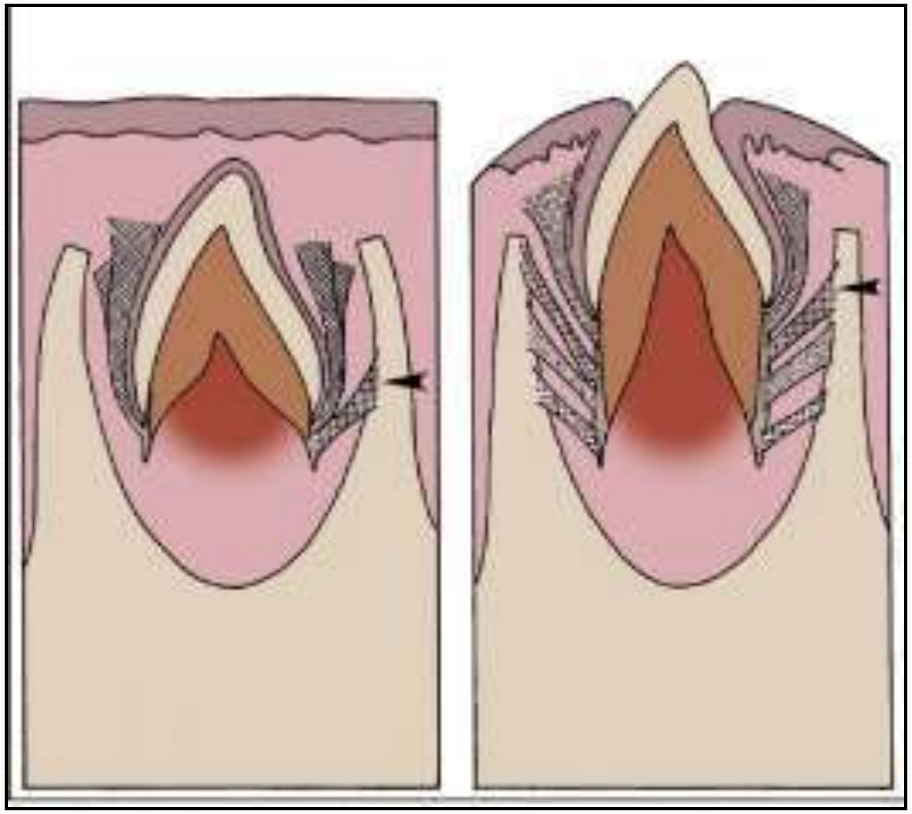


- This collagen assembles as collagen bundles extending from the bone and cementum surfaces to establish continuity across the ligament space and thereby secure an attachment of the tooth to the bone.

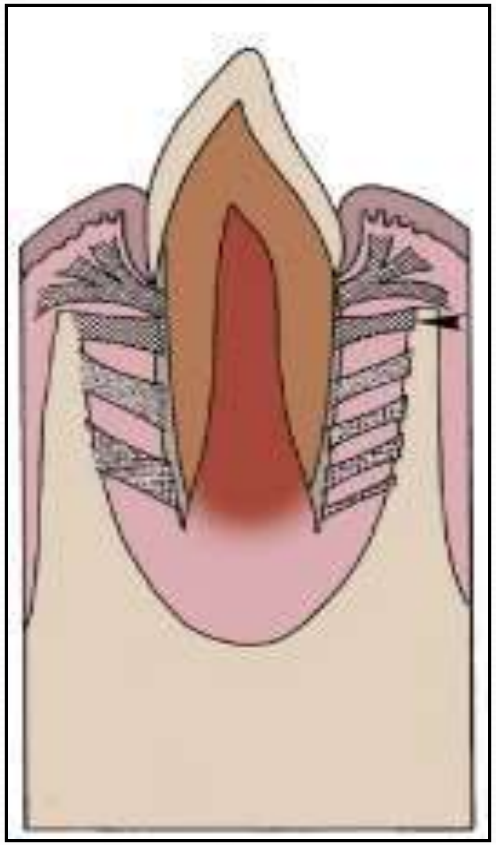
- Eruptive tooth movement and the establishment of occlusion modify this initial attachment.



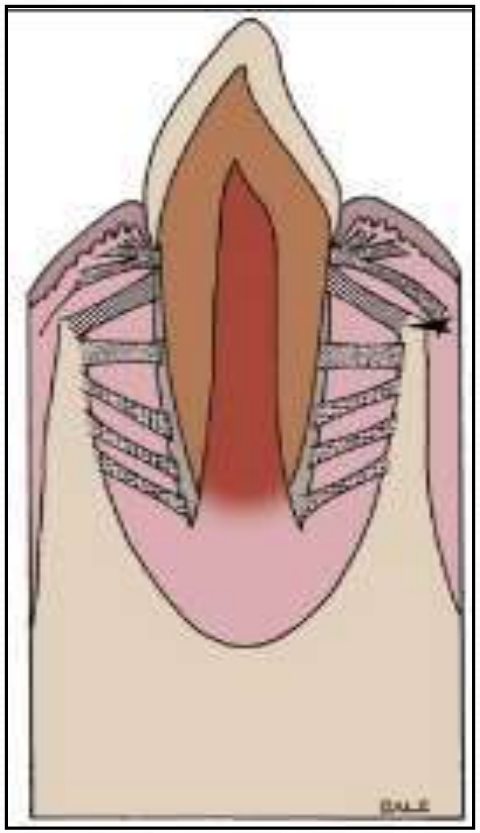
- Before eruption, the CEJ is apical to alveolar crest and the fiber bundles are directed obliquely towards crown.



- During initial tooth movement, the CEJ and alveolar crest are coinciding in height and the fiber bundles becomes horizontal.

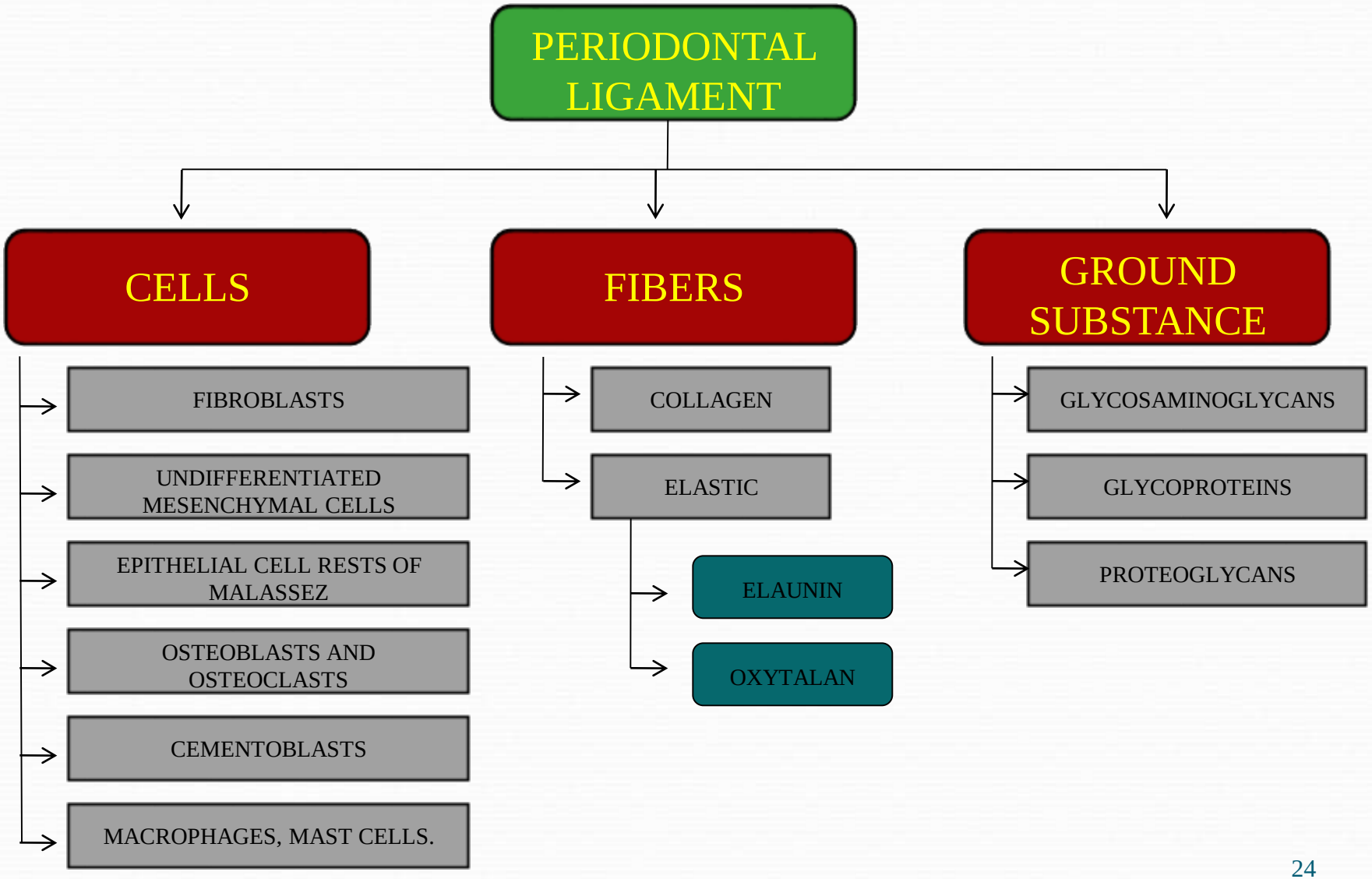


- When the tooth finally comes into function, the CEJ is coronal to the alveolar crest. Now once again the fiber bundles becomes oblique but towards apical, termed the alveolar crest fibers.

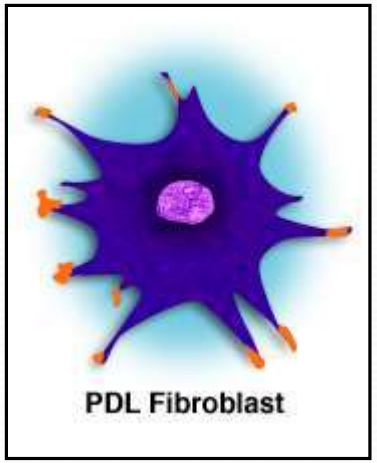


COMPONENTS OF THE

PERIODONTAL LIGAMENT


PERIODONTAL LIGAMENT
CELLS
FIBERS
GROUND SUBSTANCE
FIBROBLASTS
UNDIFFERENTIATED MESENCHYMAL CELLS
EPITHELIAL CELL RESTS OF MALASSEZ
OSTEOBLASTS AND OSTEOCLASTS
CEMENTOBLASTS
MACROPHAGES, MAST CELLS.
COLLAGEN
ELASTIC
ELAUNIN
OXYTALAN
GLYCOSAMINOGLYCANS
GLYCOPROTEINS
PROTEOGLYCANS

CELLS



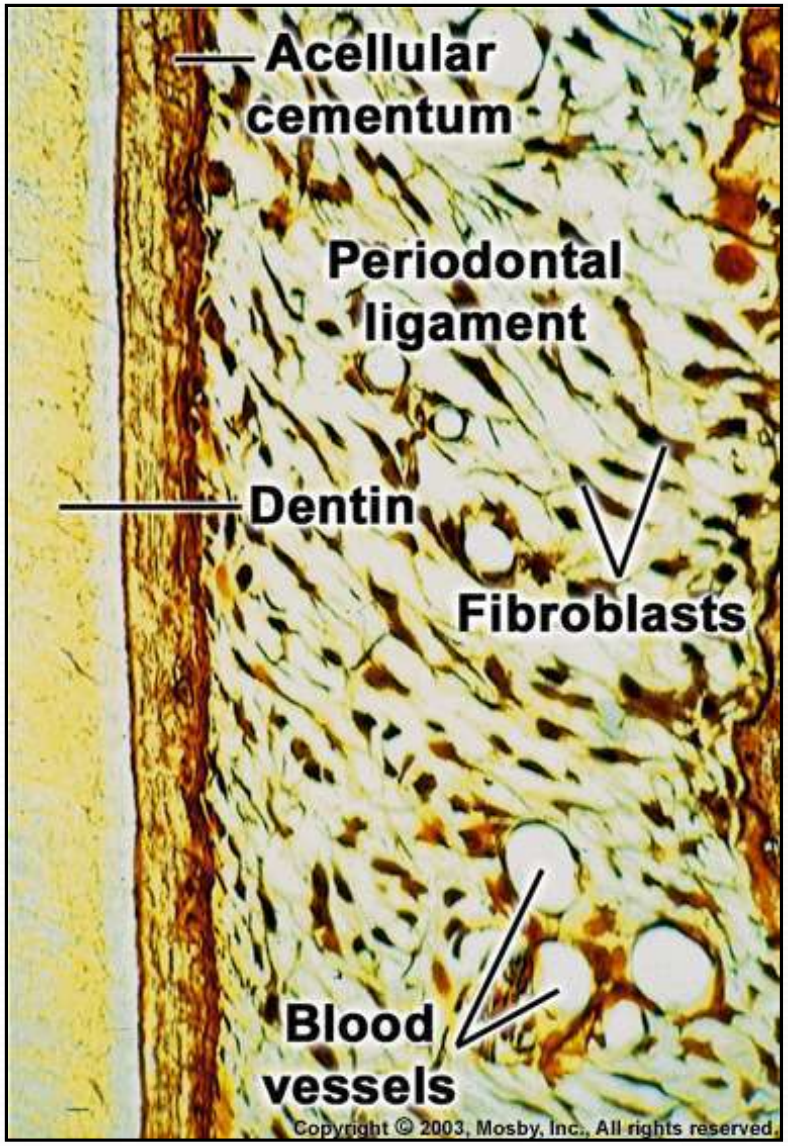
FIBROBLASTS:

- Principal cells of the periodontal ligament.

- Can be called as 'architect, builder and caretaker' of the periodontal ligament.

- Characterized by an ability to achieve an exceptionally high rate of turnover of extracellular compartment, in particular collagen.

- Cells are large, with extensive cytoplasm containing rough endoplasmic reticulum, golgi complex, and secretory vesicles associated with protein synthesis and secretion.



- Fibroblasts are aligned along the general direction of fiber bundles (long axis parallel to the direction of collagen fibrils) and with extensive processes that wrap around the fiber bundles.

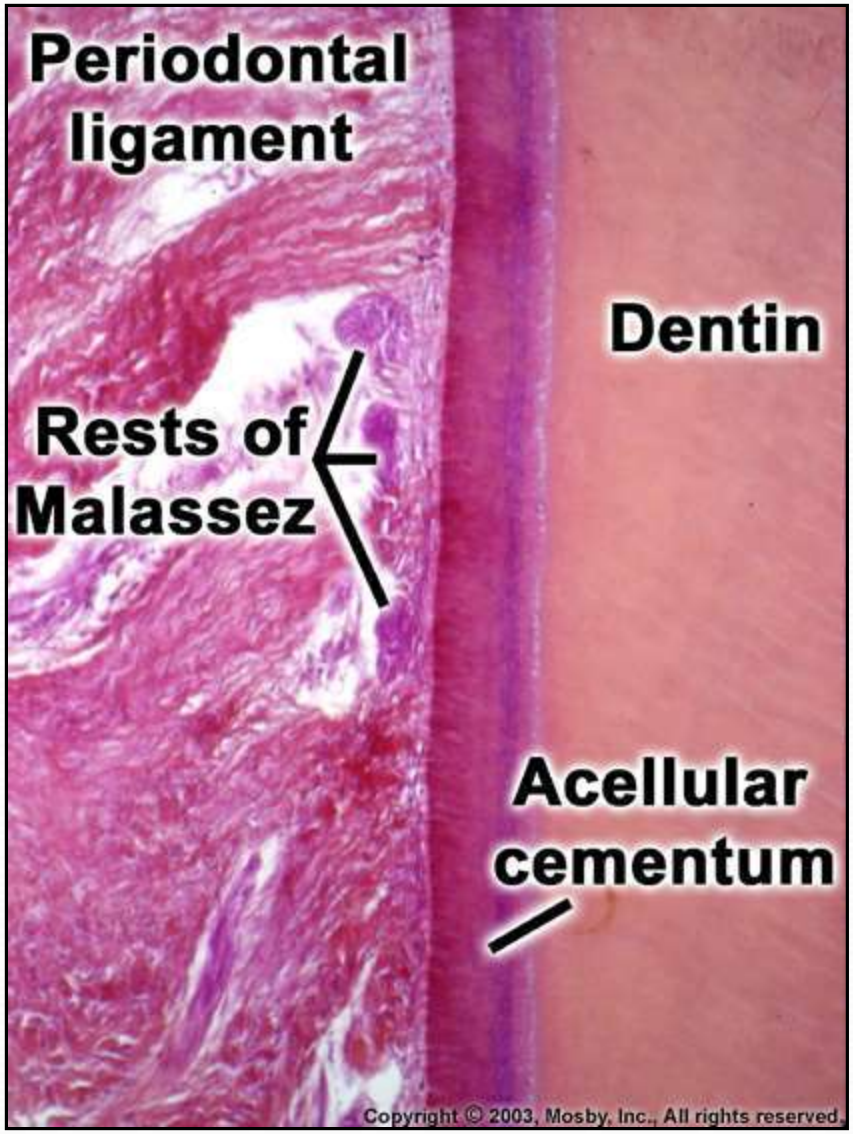
- **Function:** They are involved in the remodeling of collagen, simultaneously synthesizing and degrading collagen.

UNDIFFERENTIATED MESENCHYMAL CELLS:

- These cells are the progenitor cells that have the ability to undergo mitotic division.
- They have a perivascular location.
- They are source of new cells for the periodontal ligament.
- These cells are in a steady state as the production of new cells is balanced by cell death.

EPITHELIAL CELLS:

- Epithelial cells in PDL are remnants of Hertwig's epithelial root sheath (Cell rests of Malassez).
- They are round to ovoid cells with central darkly stained nuclei.
- These cells are found close to the cementum and are abundant in the furcation area.



- The epithelial cells persist as a network, strands, islands, or tubulelike structures near and parallel to the root surface. In cross section they appear clusterlike.

- Can develop into pathological cysts and tumors.

- These cells may calcify to form cementicles.

BONE & CEMENTUM CELLS:

- Osteoblasts line the bone surface.

- Osteoclasts are large multinucleated cells found in the Howship's lacunae at resorption sites.

- Cementoblasts line the surface of cementum. They are round cells with centrally placed nuclei.

FIBRES

COLLAGEN

- It is a protein.
- Composed of different amino acids:

  Glycine

  Proline

  Hydroxyproline

  Hydroxylysine.

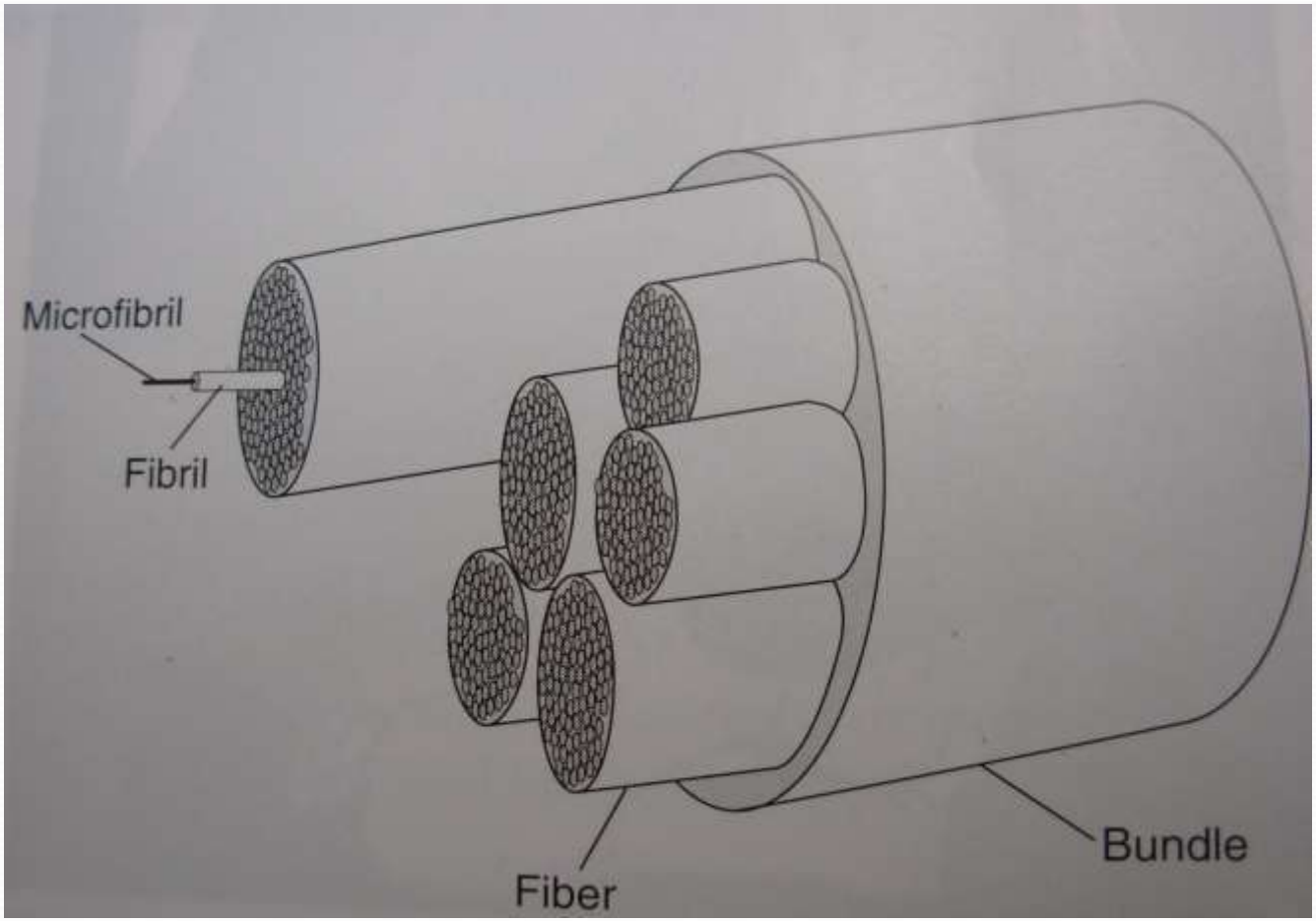
Amount of collagen in a tissue can be determined by its hydroxyproline content.

- Collagen biosynthesis occurs inside the FIBROBLASTS .

Tropocollagen molecules.

Microfilaments

Fibrils


Microfibril
Fibril
Fiber
Bundle

- Tropocollagen molecules aggregate with a quarter stagger which result in overlap zones.
- These zones are responsible for the characteristic banding in collagen fibers.
- The band of a typical collagen fiber have a characteristic periodic transverse striation of 64nm .

FIBRES

COLLAGEN FIBERS:

- The predominant collagens of the PDL are Types I, III and XII.

- Individual fibril diameter is 50 – 60 nm.

- Vast majority of collagen fibrils in PDL are arranged in definite & distinct fiber bundles approximately 5 microns in diameter.

- Each bundle resembles a “spliced rope”: the individual strands can be continually remodeled while the overall fiber maintains its architecture & function.

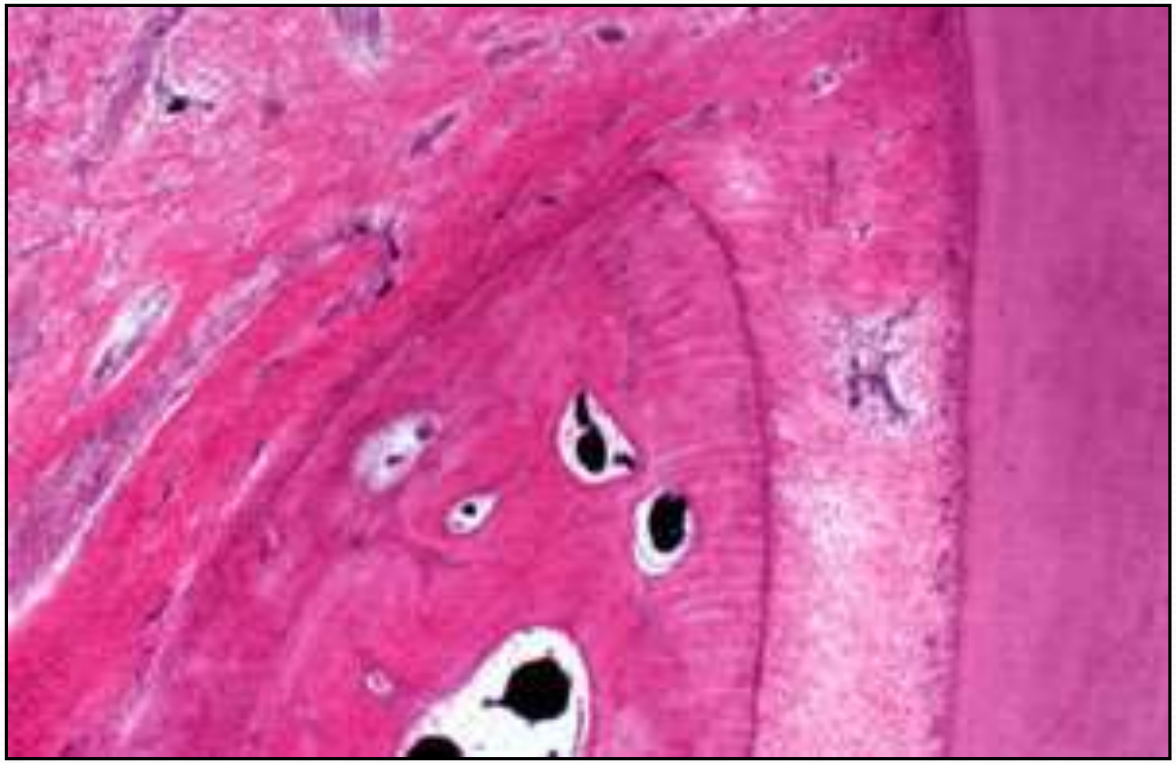
PRINCIPAL FIBERS OF PERIODONTAL LIGAMENT

1. Alveolar crest group :

- Attached to the cementum just below the CE junction and running downward and outward to insert into the rim of the alveolar bone.

- The alveolar crest fibers are the most coronal of the dentoalveolar group of periodontal ligament fibers.

Function: Resist tilting, intrusive, extrusive and rotational forces.



2. Horizontal group :

- Just apical to the alveolar crest group, running at right angles to the long axis of the tooth from cementum to bone and roughly parallel to the occlusal plane of the arch.

- Function: Resist horizontal and tipping forces.

3. Oblique group :

- Most numerous in the PDL and running from the cementum in an oblique direction to insert into the bone coronally.

- Predominant, occupy nearly 2/3rd of the ligament space.

- Function: Resist apical displacement of tooth by vertical and intrusive forces.

4. Apical group:

- Radiating from the cementum around the apex of the root to the bone, forming the base of the socket.
- Function: Resist forces of luxation

  May prevent tooth tipping

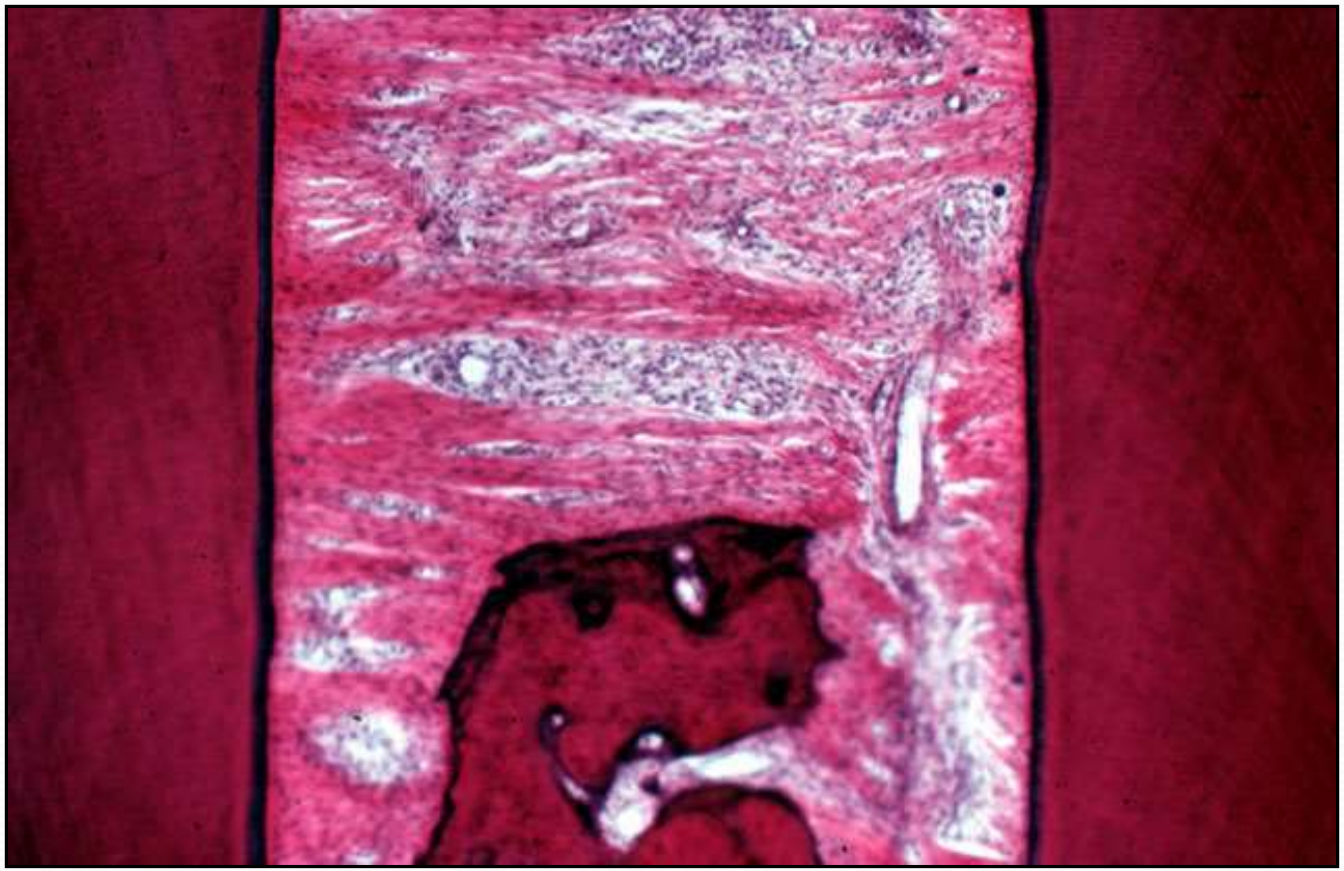
  Protect delicate blood and lymph vessels and nerves traversing the PDL space at the apex.
- These fibers are not seen in incompletely formed roots.

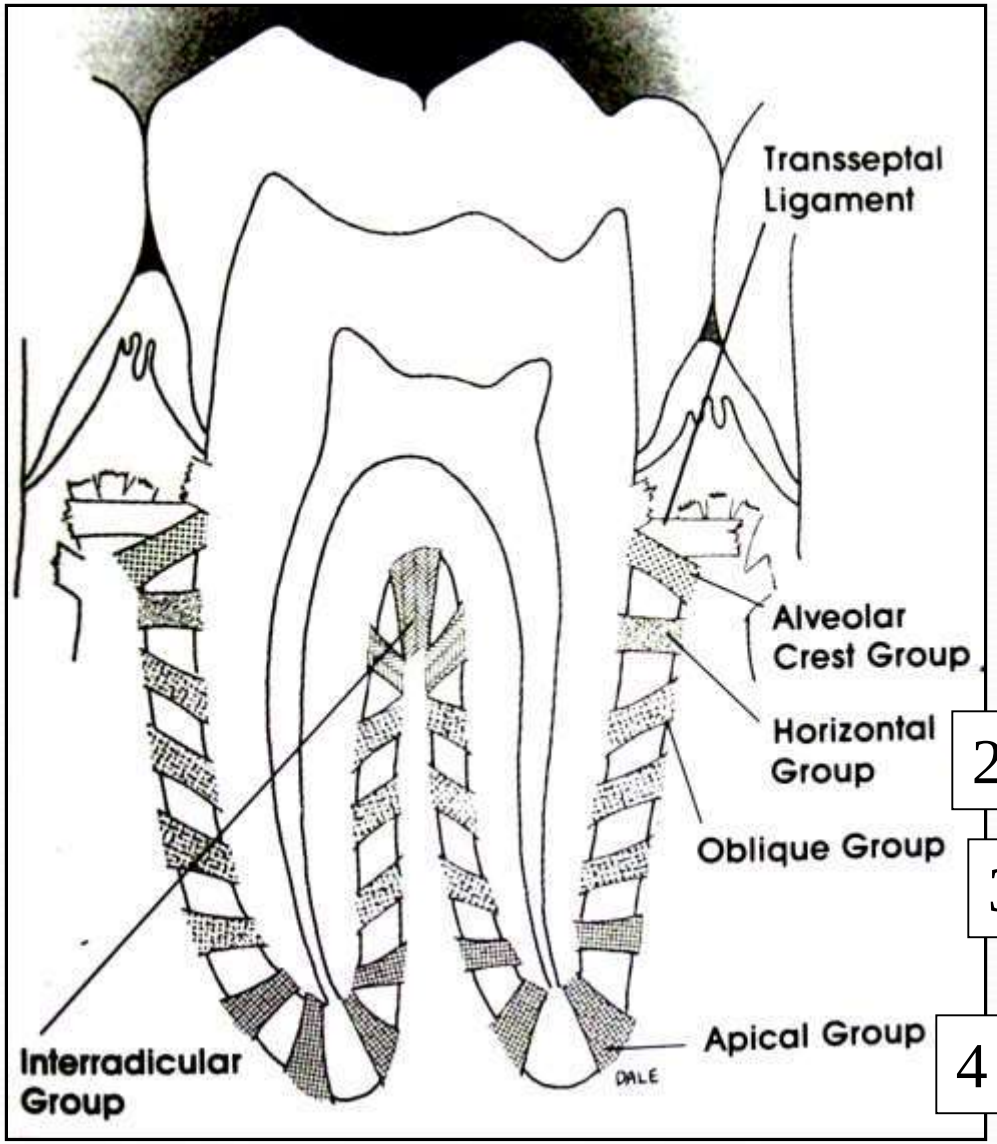
5. Interradicular group :

- Found only between the roots of multirooted teeth and running from the cementum into the bone, forming the crest of the interradicular septum.

- Function: Resist tooth tipping, torquing, and luxation.

Transeptal fibers:



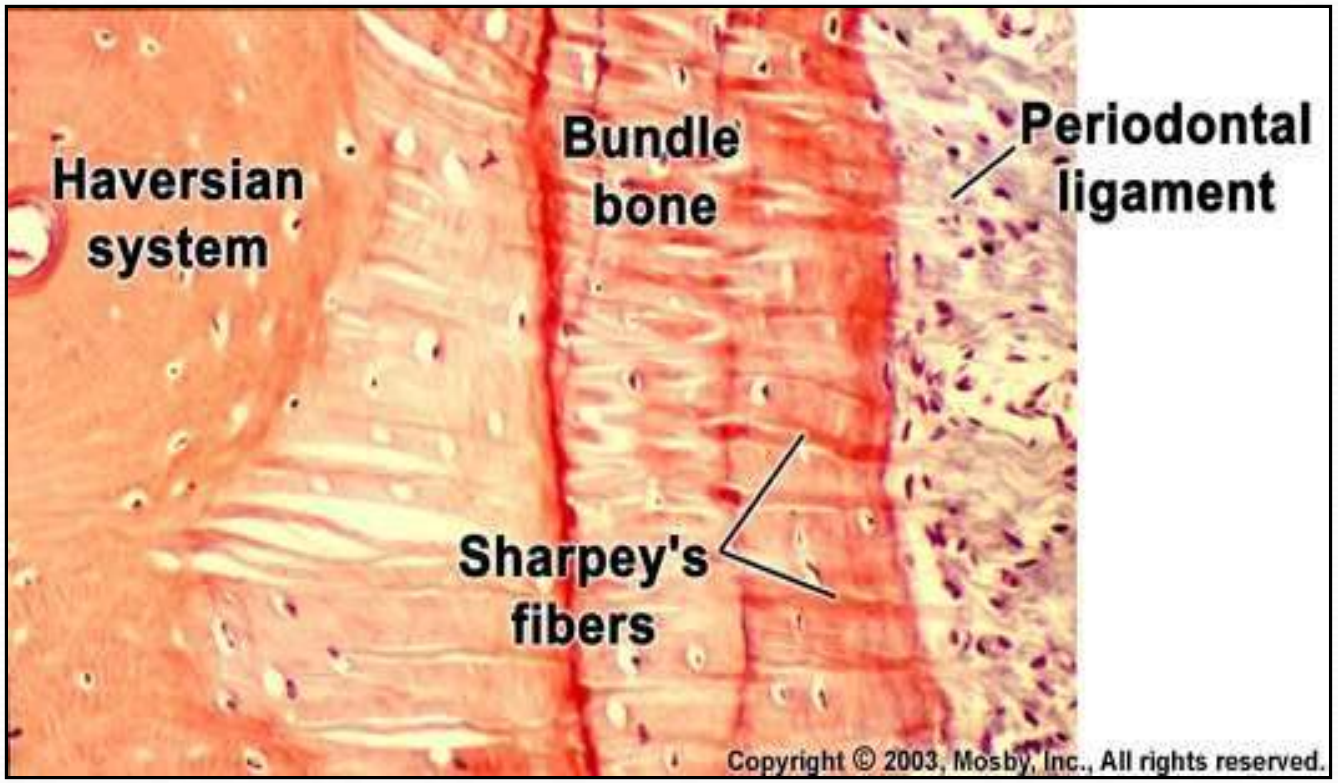

Transseptal Ligament
Alveolar Crest Group
1
Horizontal Group
2
Oblique Group
3
Apical Group
4
Interradicular Group
5
DALE

SHARPEY'S FIBERS:

- At each end, all the principal fibers of the periodontal ligament are embedded in cementum or bone. The embedded portion is referred to as "Sharpey's fibers".

- Sharpey's fibers are fully mineralized in primary acellular cementum and partially mineralized at their periphery in cellular cementum and bone.

Under electron microscope they appear as projecting stubs covered with mineral clusters.



INTERMEDIATE PLEXUS:

- The principal fibers frequently follow a wavy course from the cementum to the bone, giving rise to a zone of distinct appearance: the intermediate plexus.

- The plexus was considered to be an area of high metabolic activity, in which splicing and unsplicing of the fibers might occur.

- Research over the last few years has proved that once cemental fibers meet and fuse with osseous fibers, no plexus exists.

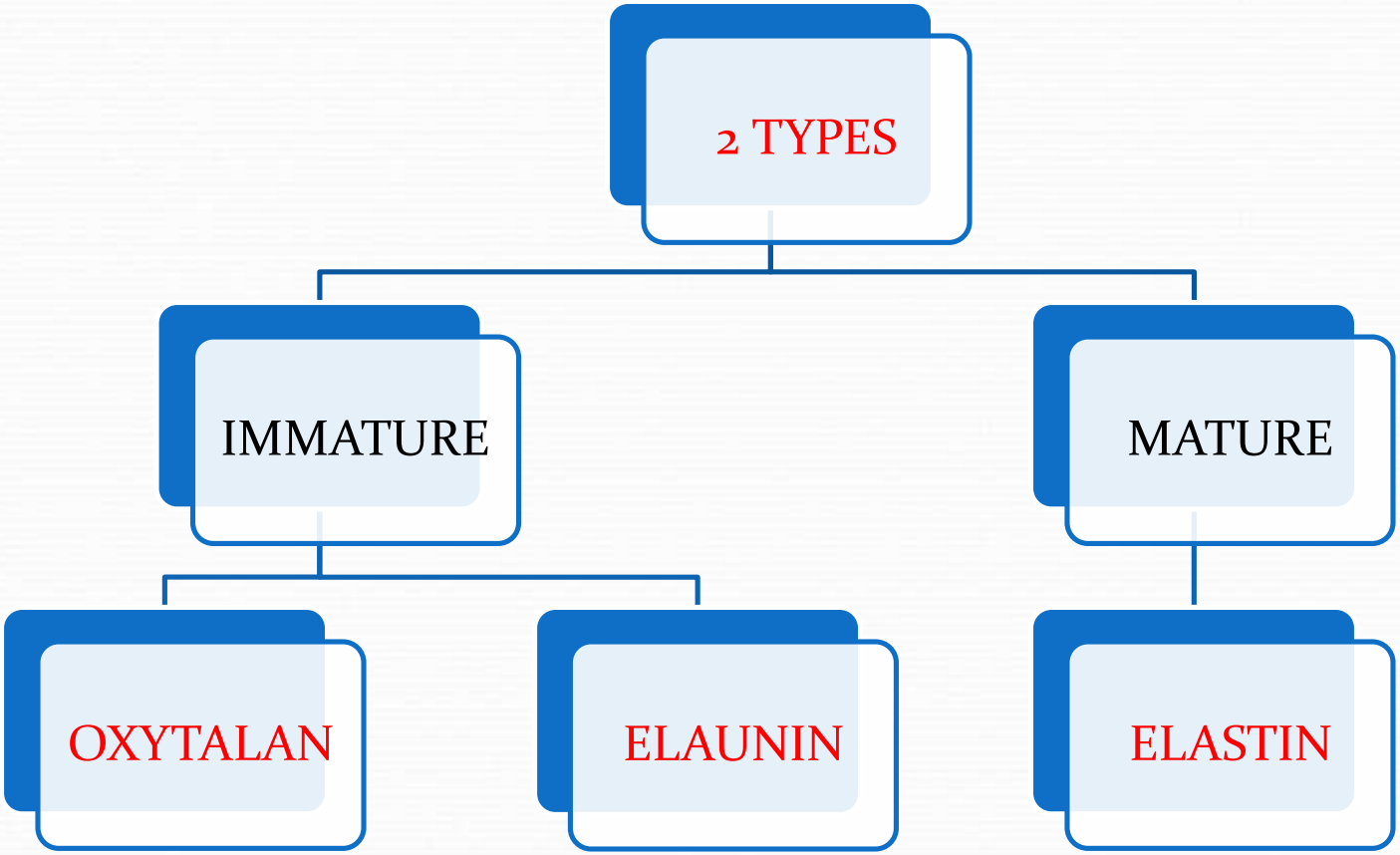
- Zone of shear: a site for remodeling during eruption is believed to lie near the center of the periodontal ligament.

A specific type of waviness called crimping is reported in collagenous tissues which is best seen under polarizing microscope.

INDIFFERENT FIBER PLEXUS:

- Small collagen fibers associated with the large principal collagen fibers have been described.
- These fibers run in all directions, forming a plexus called indifferent fiber plexus.
- It is generally considered to be an artifact produced by preparation.

ELASTIC FIBERS:



In humans, mainly oxytalan fibers are present.

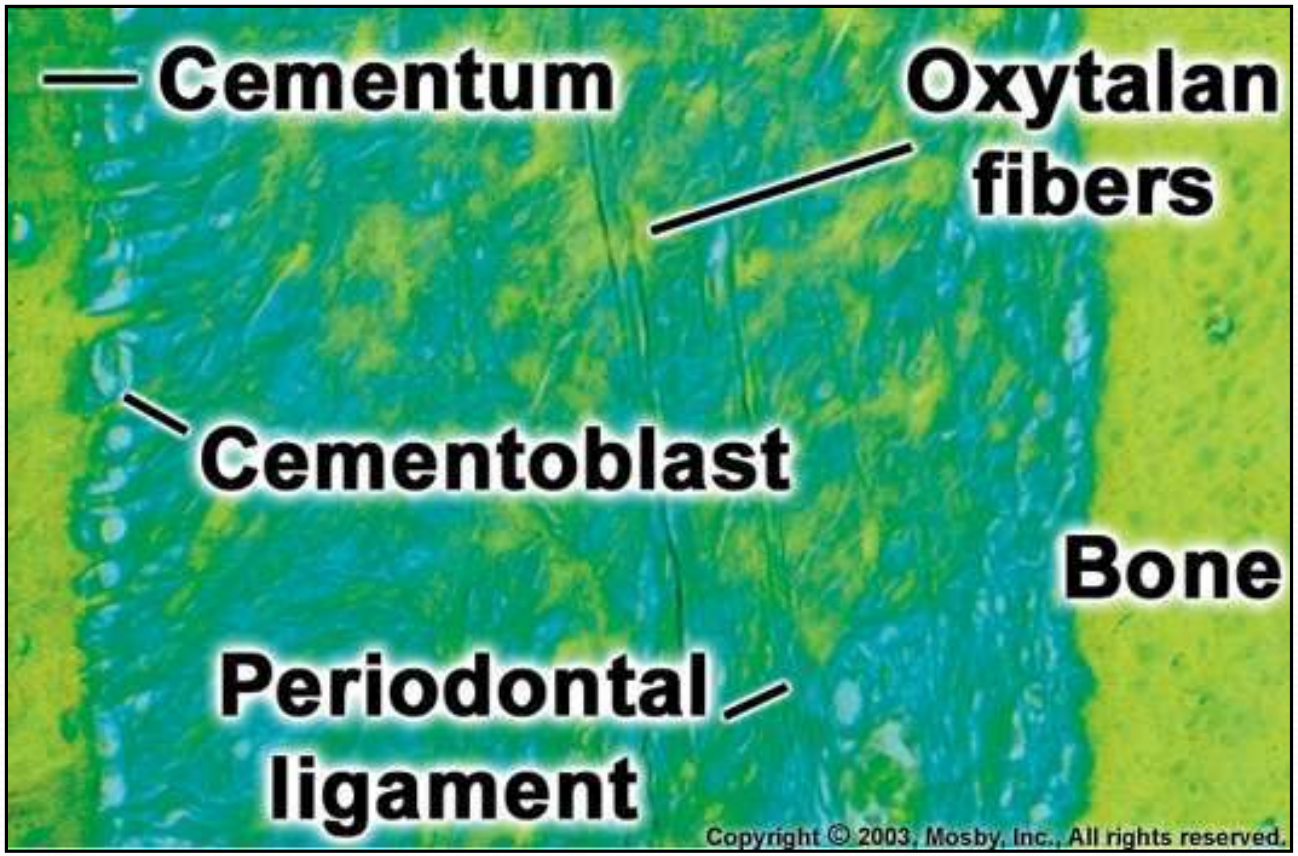
Oxytalan fibers:

- They consist of a microfibrillar component and are approximately 0.5µm to 2.5µm in diameter.

- They constitute not more than 3% of extracellular fiber composition.

- Bundles of microfibrils run more or less vertically from cementum surface of root to apically, that surrounds the root and terminates in the apical complex of arteries, veins & lymphatics.

- Function: Thought to regulate vascular flow in relation to tooth function. They are said to be thicker and more numerous in teeth that carry abnormally high loads.



Elaunin fibers:

- Represent another form of immature elastic fibers consisting of bundles of microfibrils embedded within a small quantity of elastin.

- They form a network together with oxytalan fibers, extending from cementum to bone & sheathing the collagen fibers of PDL.

GROUND SUBSTANCE

- The ground substance is a gel like matrix in which are embedded the cellular and fibrous components of the ligament.

- Mainly consists of hyaluronate, glycosaminoglycans, proteoglycans and glycoproteins.

- Ground substance consists of 70% water and this is thought to be significant in the tooth's ability to withstand loads.

Function: Ion & water binding and exchange

control collagen fibrillogenesis &

fiber orientation.

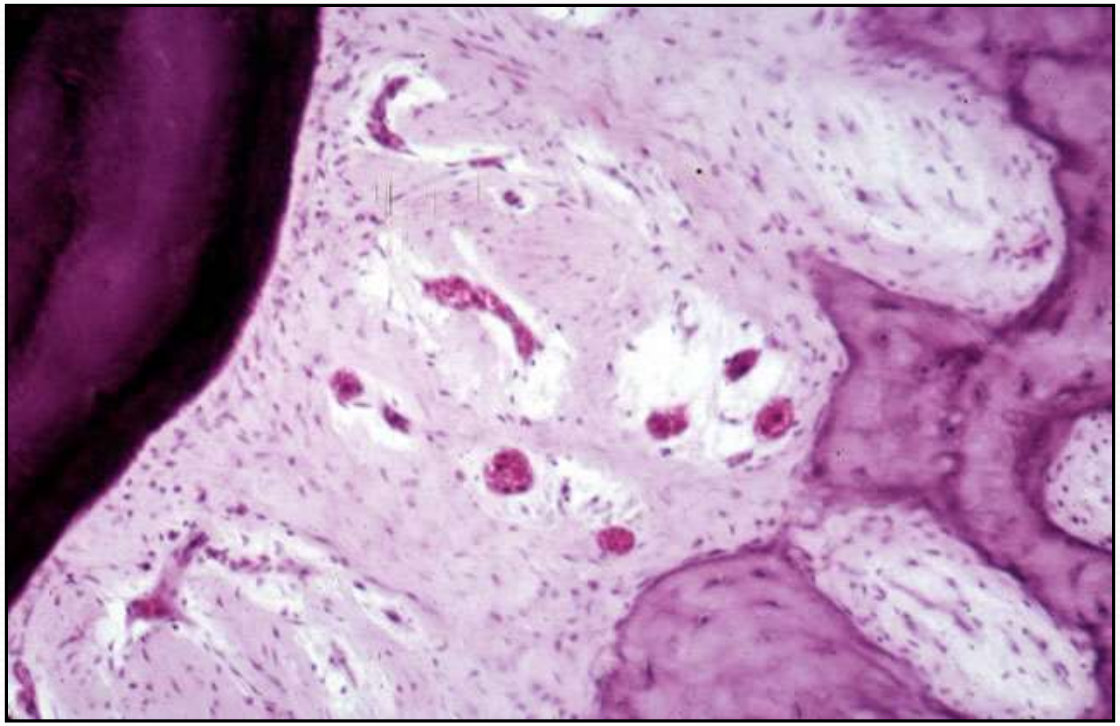
OTHER STRUCTURES PRESENT IN THE PERIODONTAL LIGAMENT

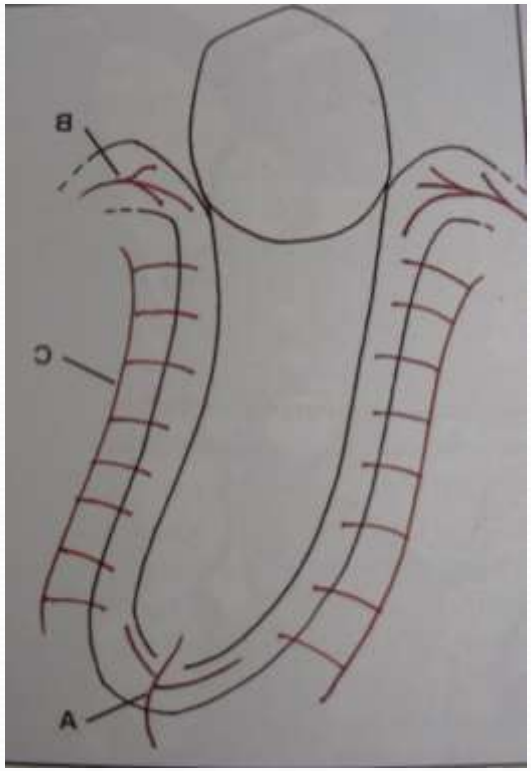
BLOOD VESSELS:

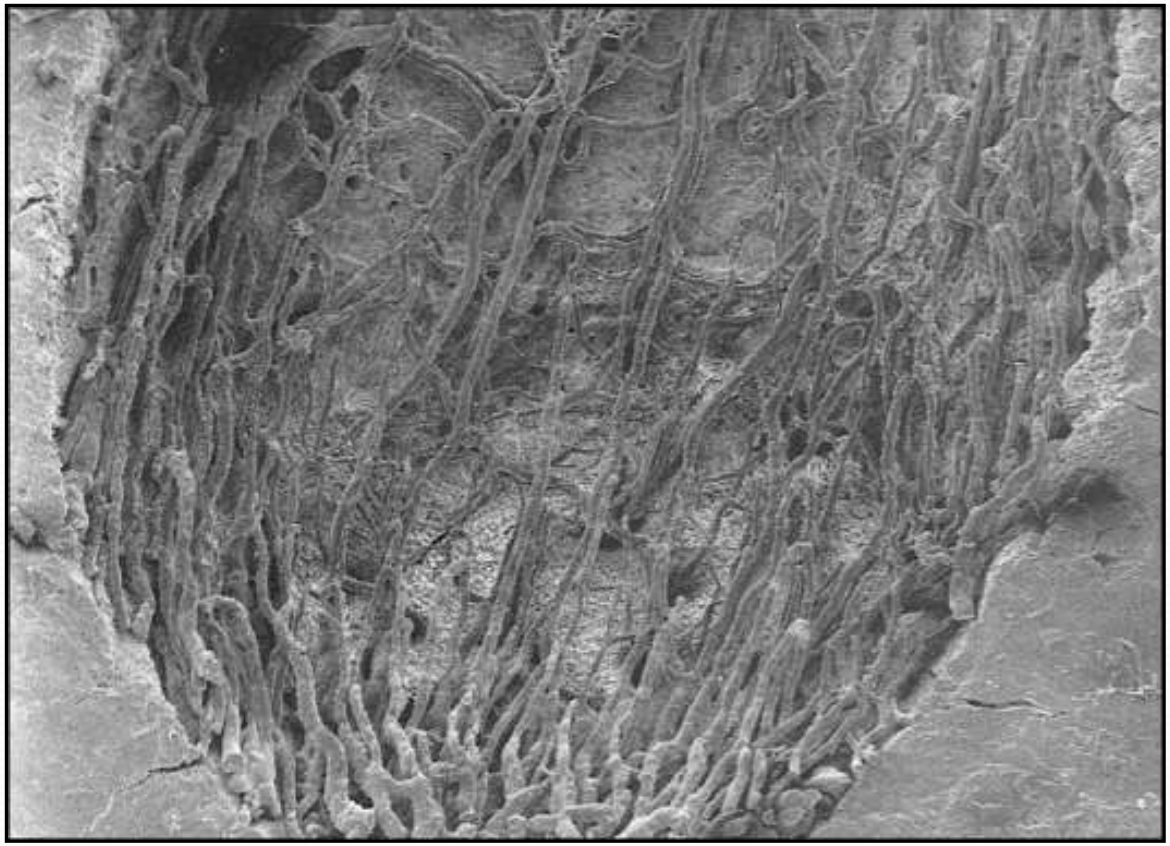
- The PDL is exceptionally well vascularized, which reflects the high rate of turnover of its constituents.

- The main blood supply of the PDL is from the superior and inferior alveolar arteries.

- Branches in the periodontal ligament from
  - apical vessels
  - intra-alveolar vessels (perforating arteries)
  - branches from gingival vessels







Extensive vasculature of the periodontal ligament with many transverse connections and the thickened venous network at the apex.

LYMPHATICS:

- Lymph vessels follow the path of venous drainage.

- The flow is from the ligament towards & into the adjacent alveolar bone.

NERVES:

- All PDL innervations are mediated by the dental branches of the superior and inferior alveolar nerves.

- The PDL has functionally 2 types of nerve fibers:

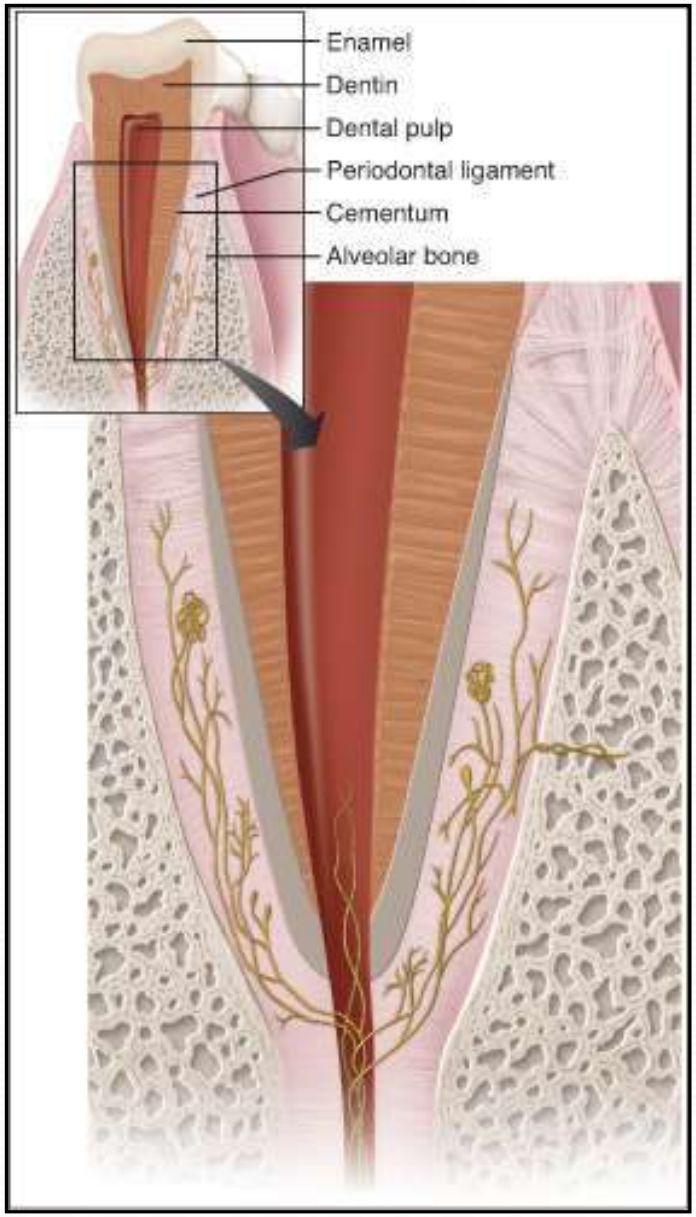
  (a) sensory

  (b) autonomic

- The autonomic fibers are associated with the PDL vessels and thought to affect regional blood flow.

- Large myelinated & small non-myelinated nerve fibers run from the apical region towards the gingival margin and are joined by fibers entering laterally through the foramina of socket wall.

- The apical region contains more nerve endings than elsewhere.



- Four types of neural terminations have been described:

(a) Free nerve endings: that ramify in a treelike configuration. Such endings originate from unmyelinated fibers and are thought to be mechano-ceptors and nociceptors.

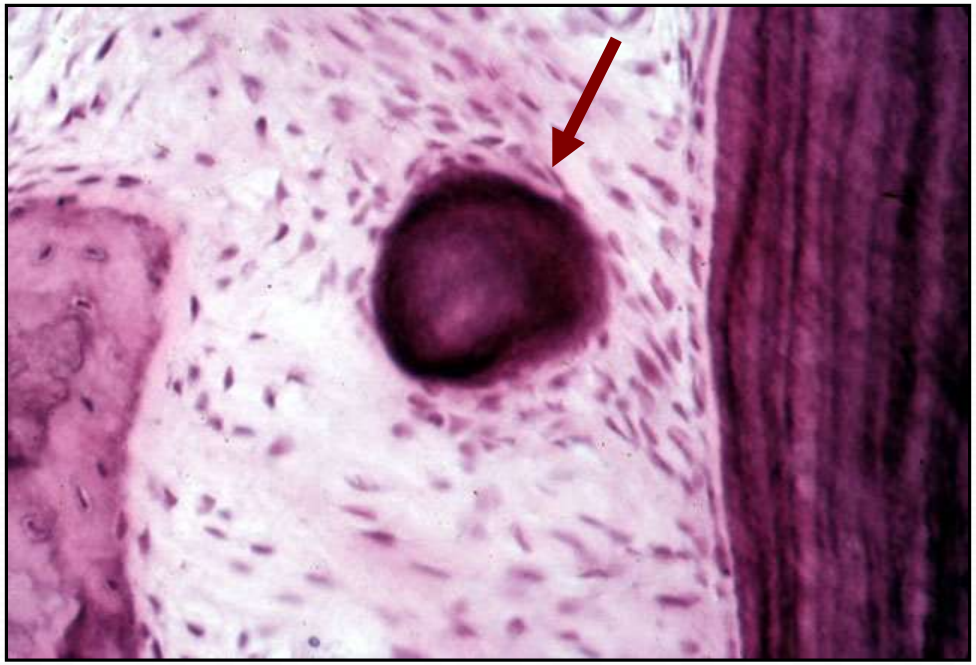
(b) Ruffini' s corpuscles: myelinated fibers whose physiologic function is mechanoception.

(c) Coiled Meissner's corpuscles: found in the mid-region of the PDL. Their function has not yet been determined.

(d) Spindlelike endings: they have the lowest frequency and are found associated with the root apex. They are surrounded by a fibrous capsule.

CEMENTICLES:

Calcified bodies called cementicles are sometimes found in the PDL.



FUNCTIONS OF THE PERIODONTAL LIGAMENT

- **Physical**
- **Formative and Remodelling**
- **Nutritional and Sensory**
- **Regulation of PDL width**

SUPPORTIVE FUNCTION:

When a tooth is moved in its socket (forces created by mastication / orthodontic treatment)

↓

Ligament is compressed

↓

Compressed part provides support for the loaded tooth

The collagen fibers, ground substance (70% H_2O) and pressure of blood in the vessels provide a

↓

CUSHION

- Provision of a soft tissue "casing" to protect the vessels and nerves from injury by mechanical forces.
- Transmission of occlusal forces to the bone.
- Attachment of the teeth to the bone.
- Maintenance of the gingival tissues in their relationship to the teeth.
- Resistance to impact of occlusal forces (shock absorption)

  - Tensional theory
  - Viscoelastic theory
  - Thixotropic theory

SENSORY FUNCTION:

- Periodontal ligament, through its nerve supply, provides a most efficient proprioceptive mechanism.

- This mechanism allows to detect the application of most delicate forces to the tooth and very slight displacement.

Eg: hard stone / substance is bitten.

PROPRIOCEPTION:

- It refers to the sense of position in space.

- It arises mainly from:

  mechanoreceptors in the PDL

  TMJ

- Pressure on tooth ⟶ activation of mechano-receptors ⟶ trigeminal motor nucleus

Formative and Remodelling:

- PDL and Alveolar bone cells exposed to physical forces.
- Cells of PDL participate in formation and resorption of cementum and bone.
- PDL is constantly undergoing remodelling.

NUTRITIVE FUNCTION:

- Periodontal ligament transmits blood vessels, which provide anabolites & other substances required

  -- by the cells of ligament,
  -- by the cementocytes &
  -- presumably by more superficial osteocytes

- The blood vessels are also concerned with the removal of catabolites.

Regulation of PDL width:

- Cells of the periodontal ligament have the capacity to resorb and synthesize the extracellular substance of connective tissue of ligament, alveolar bone & cementum.

- Mechanism of homeostasis is not known.

- If the balance between synthesis & resorption is disturbed, the quality of tissue formed will be changed.

- Eg: Vitamin C deficiency leads to loss of teeth.


Thank you very much!!