JUNCTIONAL EPITHELIUM

CONTENTS

JUNCTIONAL EPITHELIUM

INTRODUCTION

The oral cavity is lined by a mucous membrane that is continuous anteriorly with the skin of the lip and posteriorly with the mucosa of the soft palate and pharynx. Oral mucosa has three varieties;

1. Masticatory mucosa - hard palate and part of alveolar process (gingiva)
2. Specialized mucosa - dorsum of tongue.
3. Lining mucosa - lip, vestibular fornix, alveolar mucosa, floor of mouth, soft palate.
   - The gingiva is divided anatomically into marginal, attached and interdental areas[1].
   - Free marginal gingiva adheres closely to the tooth surfaces and its slightly rounded in periphery forms the lateral, or soft tissue, wall of the gingival sulcus.

The tissues that make up free marginal gingiva includes

a. The oral gingival epithelium coronal to gingival groove.
b. Oral sulcular epithelium (formerly called oral sulcular epithelium).
c. Junctional epithelium (previously called attachment or crevicular epithelium).

Crevicular and sulcular epithelium have been used to denote cells extending from the crest of the free marginal and interdental gingiva to the most apical extent of epithelium in the region of cemento enamel junction[4].

JUNCTIONS IN THE ORAL MUCOSA[5]:

- The Mucocutaneous junction (between the skin and mucosa)
- The Mucogingival junction (between the gingiva and alveolar mucosa).
- The interface between the gingiva and the tooth (the Dentogingival junction) is of considerable anatomic and clinical importance.

MUCOCUTANEOUS JUNCTION:

- The skin, which contains hair follicles and sebaceous and sweat glands, is continuous with the oral mucosa at the lips.
- The mucocutaneous junction is a transitional region where appendages are absent except for a few sebaceous glands (situated mainly at the angles of the mouth).

MUCOGINGIVAL JUNCTION:

- Although masticatory mucosa meets lining mucosa at several sites, none is more abrupt than the junction between attached gingiva and alveolar mucosa.
- This junction is identified clinically by a slight indentation called the ***mucogingival groove*** and by the change from the bright pink of the alveolar mucosa to the paler pink of the gingiva.

DENTOGINGIVAL JUNCTION:

♦ The region where the oral mucosa meets the surface of the tooth is a unique junction of considerable importance because it represents a potential weakness in the otherwise continuous epithelial lining of the oral cavity.

♦The bacteria that are inevitably present on the tooth surface continually produce toxins capable of eliciting inflammation and damage if they enter the mucosal tissues.

♦ The junction between the epithelium and the enamel is the principal seal between the oral cavity and the underlying tissues, and understanding the nature of this union is important.

JUNCTIONAL EPITHELIUM:

◙ **Junctional Epithelium** is the layer of epithelial cells united to the surface of the crown or root by hemidesmosomes and a basal lamina and has its sloughing surface at the base of the gingival sulcus[10].

◙ The junctional epithelium consists of a collarlike band of stratified squamous non keratinizing epithelium[1].

◙ Junctional epithelium form and maintain a tight seal against the mineralized tooth surface, the so-called epithelial attachment (Schroeder and Listgarten,1977)[7].

Less than a century ago these structures were very poorly described. It was believed that the fibers of the ligament lay parallel to the tooth surface and that the gingival contacted the tooth at the cemento-enamel junction.

With the advent of ***electron microscopy*** in the early 1960s, it became possible to provide new factual information pertinent to this region.

It is commonly accepted that the junctional epithelium exhibits several unique structural and functional features that contribute to prevent pathogenic bacterial flora from colonizing the subgingival tooth surface, and this is through

♦ First, junctional epithelium is firmly attached to the tooth and thus forms an epithelial barrier against the plaque bacteria.

♦ Second, it allows the access of GCF, inflammatory cells and components of the immunological host defense to the gingival margin.

♦ Third, junctional epithelial cells exhibit rapid turnover, which contributes to the host–parasite equilibrium and rapid repair of damaged tissue.

♦ Cells of the junctional epithelium have an endocytic capacity equal to that of macrophages and neutrophils, and that this activity might be protective in nature.

♦ The attachment of the junctional epithelium to the tooth is reinforced by the gingival fibers, which brace the marginal gingiva against the tooth surface. For this reason, the junctional epithelium and the gingival fibers are considered a functional unit, referred to as the ***dentogingival unit***[1].

DEVELOPMENT OF JUNCTIONAL EPITHELIUM[4]:

Developmental origin of junctional epithelium is not clear, Accoring to some studies, the controversies are

1. Junctional epithelium originates from the reduced enamel epithelium, but its characteristic features suggests that phenotype is locally controlled.

2. Develops from down growth of oral epithelium.

3. After surgery structure similar to junctional epithelium is reformed from cells of adjacent mucosal epithelium.

It has been proposed that the junctional epithelium, which was originally derived from the reduced enamel epithelium, may be replaced in time by a junctional epithelium formed by basal cells originating from the oral gingival epithelium (Ten Cate, 1996)[7].

According to Grant,

- After amelogenesis, the ameloblasts form a basal lamina and hemidesmosomes, which contribute to the primary epithelial attachment.
- As the erupting tooth approaches the oral cavity, the reduced enamel epithelium covering the erupting crown nears the epithelium covering the alveolar ridge.
- The basal cell layers of these epithelia begin to proliferate. As the cusps emerge into the oral cavity, the proliferating cells on the outer surface of the reduced enamel epithelium start to migrate toward the newly formed sulcus and desquamate into the sulcus itself.
- In the process they displace the reduced ameloblasts still adherent to the cusp tips. The area of the cusp tip, is the region where junctional epithelium first replaces reduced enamel epithelium[2].

♦ Ameloblasts which, have completed their formative function, develop hemidesmosomes, secrete basal lamina & become firmly attached to the enamel surface.

♦ After ameloblasts has laid down primary enamel cuticle, it gets shortened.

♦ The shortened ameloblasts along with other flattened cells together are called ***reduced enamel/dental epithelium***. This layer covers the whole crown till cemento enamel junction in normal conditions.

♦ Between the reduced enamel epithelium and the overlying oral epithelium is connective tissue that supports both reduced enamel epithelium and oral epithelium. When tooth eruption begins, this connective tissue breaks down.

♦ Once there is degenerative changes in connective tissue, widening of the intercellular spaces between the epithelial cells occurs as they proliferate and migrate.

♦ As a result of this, cells of outer layer of reduced dental epithelium and cells of oral epithelium proliferate and migrate into the degenerating connective tissue, eventually fusing to establish a mass of epithelial cells also known as ***epithelial cuff*** over the erupting tooth.

♦ Cell death in the middle of this epithelial plug leads to the formation of epithelium lined canal through which the tooth erupts without causing hemorrhage.

♦ From the mass of epithelium or epithelial cuff, **together with remaining reduced dental epithelium,** an epithelial component of the ***dento gingival junction*** is established in relation to the degraded connective tissue.

♦ **It is an important observation because the connective tissue determines the morphology of the dento gingival junction.**

♦ After the tip of the cusp of the erupting tooth has emerged into the oral cavity, oral epithelial cells begin to migrate over the reduced enamel epithelium in an apical direction.

♦ At this time, the attachment of gingival epithelium to tooth is maintained through the reduced ameloblasts and their desmosomes and basal lamina adjacent to enamel surface. This is the ***primary epithelial attachment***.

♦ As eruption proceeds mitosis occurs in the basal layer of oral epithelium and in the outer layer of reduced enamel epithelium, but the ameloblasts no longer divide.

♦ **The reduced ameloblasts and other cells of reduced enamel epithelium are transformed into junctional epithelial cells and the primary epithelial attachment then becomes secondary epithelial attachment.**

♦ A process of transformation takes place where the reduced enamel epithelium gradually becomes ***junctional epithelium***. The interface between junctional epithelium and the tooth surface forms the ***secondary epithelial attachment*** made up of epithelial attachment lamina and the hemidesmosomes.

♦ **The reduced ameloblasts change their morphology** and are transformed into squamous epithelial cells that retain their attachment to the enamel surface.

♦ They undergo nuclear and cytoplasmic reorganization, including development of cytoplasmic filament reorganization, golgi apparatus and other features. The cells of the outer layer of **reduced enamel epithelium** retain their ability to divide and, because of this, continue to function as basal cells of a forming junctional epithelium.

♦ The transformed ameloblasts are eventually displaced by the mitotic activity of the basal cells. As the overgrowing epithelial cells from the cuff stratify they further separate the cells of the transformed dental epithelium from their nutritive supply, with the consequence that these later cells degenerate and create a gingival sulcus.

♦ The final conversion of reduced enamel epithelium to junctional epithelium may not **occur until 3 to 4 years after** the tooth has erupted. Immediately after all the reduced enamel epithelium has been transformed into squamous epithelium, the development of dento gingival junction may be regarded as complete.

♦ Although the **dental epithelium** contributes specifically to the development of the dentogingival junction, it is not required for the redevelopment of this junction after a gingivectomy. After surgical procedure, the junction is reestablished at the lower level on the tooth and its epithelial component comes solely from cells **stemming from the** oral epithelium[4].

EPITHELIAL ATTACHMENT AND THE CONCEPTS[10]:

Initial studies regarding junctional epithelium encountered so many

limitations;

→ The gingival could be easily displaced during extraction, cavity preparation, restorative treatment, and scaling procedures.

→ In addition histologic examination required the use of decalcifying solutions to remove tooth mineral. Enamel is soluble in these solutions and leaves a space between the dentin and the gingiva in tissue sections. So it was believed that that the subgingival space extended to the cementoenamel junction under a loose fitting gingiva.

GOTTLIEB IN 1921:

◘ Concluded that there is no such space. Rather, the gingiva forms an organic union with the enamel and is firmly bound to it, and he named it as (epithelansatz or epithelial attachement).

◘ He proposed that this epithelial attachment and its gingiva gradually stripped from the tooth, like the peel from an orange.

ORBAN 1944:

● Incorporated the views of **Meyer, Becks, and Weski** by stating that the separation of the epithelial attachment cells from the tooth surface involved preparatory degenerative changes in the epithelium.

● This statement was a sharp departure from Gottlieb's concept of production of cornified cuticle and becomes part of the reduced enamel epithelium.

WAERHAUG 1952:

◙ Waerhaug reported clinical, histologic and experimental studies which led to the opposite conclusion.

◙ He described the gingiva as being separated from the tooth by a capillary space, forming an epithelial cuff.

◙ This cuff was believed to be weakly adherent to the tooth, and could be displaced from the tooth surface and then replaced against it without diminishing the strength of the adhesion.

STERN 1962:

◘ In 1962 Stern first demonstrated that the ultra structure of the epithelium of the ameloblast-enamel junction (**the *dentogingival junction)*** of rat incisor consists of a basal lamina and hemidesmosomes, and that the basal lamina has components namely lamina lucida and a lamina densa

Recently, these concepts have been replaced by the concept of the ***junctional epithelium****,* a tissue capable of forming and renewing itself continuously throughout life.

It forms at its base, migrates coronally and desquamates at its surface, all the while maintaining a biologic attachment to the tooth. Thus, the former relatively **static concepts have been replaced by a dynamic concept**[10].

THE EARLY STUDIES: MAX LISTGARTEN[8]**:**

◘ The nature of the epithelial attachment apparatus in man was unveiled primarily by Max during the time period up to 1967.

◘ Based on transmission electron microscopic findings, he demonstrated, for the first time, that an attachment apparatus around erupted teeth did exist.

◘ Max correctly concluded that a reduced enamel epithelium was not needed for an epithelial attachment apparatus to form *de novo*. On the contrary, with no other epithelial source nearby, the most likely source for the new junction was the keratinized oral gingival epithelium at the wound edge, an epithelium with a different phenotype.

THE EARLY STUDIES: HUBERT SCHROEDER[8]**:**

● According to Dr. Jens Waerhaug, a firm attachment between the epithelium of the "physiological pocket" and the enamel surface did not exist.

● In1968, Hubert concluded that, in humans, the epithelial attachment is mediated by a basement lamina produced by the attachment epithelium, that this attachment extends from the cemento-enamel junction to the gingival sulcus bottom, and that it withstands any mechanical force applied.

● After discussions with Hans Mühlemann, Hubert agreed to use the term "junctional epithelium", which had been suggested by Anderson and Stern (1966).

● Schroeder, (1970, 1971, 1973) indicated that the junctional epithelium is a non-keratinizing, non-differentiating, fast-renewing epithelium with distensible intercellular spaces that serve as a pathway for an inflammatory exudate and neutrophilic granulocytes, as a residence for lymphocytes and monocytes, as well as for the inward diffusion of foreign molecules[8].

COLLABORATIVE STUDIES[8]:

♦ (Glavind and Zander, 1970) helped with the interpretation of Hubert's micrographs. It became clear that the reduced enamel epithelium becomes transformed into junctional epithelium while the tooth erupts. This meant that the primary attachment apparatus persists throughout the eruption process,

A NEW LOOK AT FUNCTION[8]:

? Thereafter, two questions still remained **unanswered**: Why did the neutrophilic granulocytes, as Hubert had demonstrated (Schroeder,1973), tend to accumulate in the most coronal part of the junctional epithelium? And why were up to 60% of all leucocytes in this epithelium are non-neutrophils?

● The answer to the first question was provided when Tonetti et al. (1994) demonstrated that the junctional epithelial cells synthesize and express IL-8 with increasing intensity as they approach the sulcus bottom. As a result, neutrophils are retained near the sulcus bottom.

● The answer to the second question was applied early on, namely, that mononuclear leucocytes, mainly lymphocytes and monocytes, might reside only

temporarily within the junctional epithelium, possibly to recognize antigens, prior to re-entering the underlying connective tissue (Schroeder, 1973)[8].

The junctional epithelial cells are adapted for adherence to the tooth surface unlike keratinized cells, which cannot adhere. This may be important following injury to the junctional epithelium and its epithelial attachment[2].

In contrast to most other epithelia,

■ There is no keratinizing epithelial cell layer at the free surface of the junctional epithelium that could function as a physical barrier.

■ The junctional epithelium fulfills this difficult task with its special structural framework and the collaboration of its epithelial and non-epithelial cells that provide very potent antimicrobial mechanisms.

■ Recent studies have shown that the junctional epithelial cells themselves may play a much more active role in the innate defense system than previously assumed, by synthesizing a variety of molecules involved in the combat against bacteria and their products[10].

CUTICULAR STRUCTURES AT THE DENTOEPITHELIAL JUNCTION:

□ Nasmyth (1839) described an organic coating over the enamel of unerupted and newly erupted teeth called **dental cuticle**. This coating, which could be floated off after placing the teeth in acid for a short time, was called **Nasmyth's membrane[3].**

□ Gottlieb, a dental histopathologist of the early 20th century, described a "primary enamel cuticle" covering the enamel of unerupted teeth. He speculated that this material was the end product of ameloblastic activity[6].

THICKNESS OF DENTAL CUTICLE[3]:

◘ The thickness of the dental cuticle as seen with the light microscope may be as much as 50 μ.m, while in electron microscopic study it appears to be much thinner (0.04 to 0.7 μ.m).

◘ The thickness is greatest at the most coronal part of the Junctional epithelium and thinner toward the cementoenamel junction.

ORIGIN OF DENTAL CUTICLE[3]:

◙ It may be that what is seen in light microscopy as a dental cuticle is an amorphous layer of coagulated tissue fluid adherent to the tooth surface. The main unsolved problem concerning the epithelial attachment is the origin and nature of the secondary dental cuticle, which mitigates almost all epithelial contact with the tooth.

◙ The true origin of the dental cuticle is still unknown, but it has been linked theoretically to a continuous secretion of basement lamina material from the Junctional epithelium.

◙ It may instead be a secretion product from the connective tissues, forming as a seepage along the tooth surface;

◙ Alternatively, it has been suggested but not proven that the cuticle originates from degenerated erythrocytes.

Much later came **Gottlieb's** well-known theories of

Primary & secondary calcified enamel cuticle:

● Primary enamel cuticle formed as an end product of the function of the ameloblasts, and of a **keratinized secondary enamel cuticle** that formed during the transformation of the ameloblasts into reduced squamous enamel epithelium.

● Gottlieb postulated that these two cuticles were intimately and organically connected, and with the epithelial cells attached to the secondary cuticle they were thus also attached to the enamel.

Listgarten was unable to confirm the presence of this structure and concluded that it was an optical artifact produced when thick ground sections were examined by light microscopy[6].

Cuticles have been classified as preeruptive and post-eruptive or acquired structures or as primary and secondary cuticles. More recent names are ***integuments*** and ***pellicles*[3].**

Although the junctional epithelium may be directly attached to enamel, cementum, or both, a number of organic layers may be interposed between the tooth surface per se and the junctional epithelium. These have been called pellicles and cuticles and their origin, composition, and importance have been the subject of debate[2].

There are a number of hypothesis related to their origin.

It has been suggested that these surface coatings be classified as[2]

1.***Endogenous*** that is of developmental origin,

2.***Acquired*** coatings, which are salivary or bacterial products.

1.***Endogenous:***

The endogenous coatings are the ones, most likely to be found between the tooth and the junctional epithelium. They include incompletely mineralized enamel matrix that forms

- **Subsurface pellicle on enamel,**
- **Reduced enamel epithelial remnants,**
- **Afibrillar coronal cementum, and the**
- **Dental cuticle**.

These may occur singly or in combination—for example, dental cuticle over coronal cementum.

Afibrillar coronal cementum:

It forms **before tooth eruption** in areas where reduced enamel epithelium has degenerated. The exposed enamel may become covered with a thin layer of coronal cementum that may eventually be covered, in turn, by junctional epithelium[2].

DENTAL CUTICLE[2]:

Dental cuticle probably is a product of the junctional epithelium. Continued production of basal lamina by the junctional epithelium may produce a thickened layer of basal lamina, which is then seen as dental cuticle.

The dental cuticle may be an acquired coating, possibly a product of inflammation.

2.**ACQUIRED COATINGS:**

Acquired coatings include **acquired surface pellicles**, which are produced by adsorption of salivary, dietary, microbial, and hematogenous materials to tooth surfaces and possibly to calculus.

♦ No cuticular matrix is present between the basal lamina and the enamel[6].

♦ Listgarten described and characterized two types of cuticular deposits on the enamel surface.

1.**TYPE A CUTICLE[6]**:

- Found on both erupted and unerupted teeth,
- Has a granular matrix with appositional lines.
- It is usually restricted to the cervical area around the cemento-enamel junction.
- Can be approximately 1 to 5 μ.m thick and up to hundreds of microns in length.
- Type A cuticle is mineralized.

Because of its structure, location, and ability to mineralize, it is thought to be a form of afibrillar, acellular cementum.

On the basis of this and other, more recent, reports, it appears that the reduced enamel epithelium is attached to the enamel surface or to cuticle A by a basement lamina and hemidesmosomes rather than through a Nasmyth's membrane or a secondary enamel cuticle[3].

2.TYPE B CUTICLE[6]:

- Is found only in erupted teeth.

- ❖ It is located between the enamel (or a type A cuticle) and the internal basal lamina of the JE.
- ❖ Type B cuticles have no appositional lines and do not mineralize.
- ❖ The current hypothesis is that type B cuticles are formed by the precipitation of tissue fluid proteins on the enamel and/or cementum surface. When slices of enamel or dentin are exposed to fresh serum, a cuticle similar to type B is deposited.
- ❖ Type B cuticles are not observed over the enamel of unerupted teeth, suggesting that the reduced enamel epithelium protects the enamel surface from contact with tissue fluids.

It was less granular than the primary cuticle, had a mottled appearance, and was connected to the Junctional epithelium by basement lamina and hemidesmosomes[3].

● When the ameloblasts finish formation of the enamel matrix, they leave a thin membrane on the surface of enamel, **the *primary enamel cuticle***. This cuticle may be connected with the interprismatic enamel substance and the ameloblasts[4].

● The surface of enamel, as well as of afibrillar cementum may exhibit a layer of homogenous, non-laminated material that does not undergo calcification and differs morphologically from epithelial attachment lamina. This material is referred *to* as ***dental cuticle[4].***

● It stains intensely with uranyl acetate, and it may extend into the gingival sulcus and beyond.

● Presumably, dental cuticle is derived from micro exudation and may consist of serum & tissue fluid components that have leaked through the dento gingival interface and have been adsorbed to the tooth surface, but this presumption is not known.

The *cuticle* may form on the crown or root in the vicinity of the junction, and is **probably protein**, since it tests positively for alpha-amino acids. It does not appear to be derived from basal lamina, because its histochemical reactions are different[10].

DENTAL PELLICLES[3]:

♦ Soon after a tooth has been cleaned and polished, the exposed surfaces of the teeth in vivo are covered by a thin (1-3μm) organic structure called the ***dental pellicle***.

♦ When less than 1 μ.m in thickness, it is sometimes called a cuticle. It cannot be removed by regular tooth brushing, not even following scrubbing with a hard bristle brush and soap or detergents in tap water, but requires polishing with an abrasive to be removed. It can be separated from the tooth by immersion in a decalcifying solution for 10 minutes, after which it can be teased off or lifted away.

♦ The pellicle consists of specific salivary proteins, some of which promote specific colonization and maintenance of indigenous oral flora, while others function as antimicrobial factors.

♦ The composition of the pellicle is variable but includes proteins, glycoproteins (mucins), and a substantial amount of lipids as well.

Although in vitro studies have shown that bacteria will adhere to hydroxyapatite, the adherence is enhanced by salivary pellicle, and the colonization of plaque on the tooth surface involves interaction between the surface of the bacteria and the absorbed pellicle.

♦ In electron micrographs of dental pellicle, the surface often has a honeycomb appearance from adherent bacteria, and bacterial plaque is apparent on the surface of the pellicle.

PRIMARY AND SECONDARY EPITHELIAL ATTACHMENT:

In classic histology, this first attachment is termed the ***primary epithelial attachment.***

During eruption, contact is established between the reduced enamel epithelium and the oral gingival epithelium. Mitotic activity increases in the reduced enamel epithelium, and changes in cell shape and organelle content take place as the cells merge with the oral mucosa to form a JE. This process gives rise to the ***secondary epithelial attachment[6].***

The junction of reduced ameloblasts to the enamel forms the ***primary epithelial attachment.*** The interface between the junctional epithelium and the tooth surface forms the ***secondary epithelial attachment[2]***.

The proliferative activity of the outer cells of the reduced enamel epithelium, which begins near the cusp tip, proceeds by degrees in an apical direction. In the process, the reduced ameloblasts are gradually displaced by the newly formed junctional epithelial cells. This process continues until the entire relatively static reduced enamel epithelium is replaced by junctional epithelium[2].

In the course of ameloblast histodifferentiation the cells pass through two phases[10];

- ✓ Forming enamel in the first, and
- ✓ Primary junctional epithelium in the second.

The epithelial cells are now referred to as the junctional epithelium, while ***epithelial attachment*** refers to the zone of attachment, its structure (i.e. basal lamina and hemidesmosomes) and its biochemical constituents.

□ When the ameloblasts become depleted and are lost, their attachment role is taken over by the ***secondary junctional epithelium,*** a derivative of the gingival epithelium. The secondary junctional epithelium is derived from undifferentiated basal cells[10].

□ The replacement of primary by secondary junctional epithelium occurs only in human or similar teeth – that is in teeth having roots coated with radicular cementum and having closed apical foramen. These teeth have coronal enamel which is formed by an enamel organ situated in a coronal position. They are referred to as rooted teeth, or teeth of limited eruption.

The elements of the epithelial attachment are produced and renewed by the adjacent DAT cells (Stallard *et al.*, 1965; Osman and Ruch, 1980) and, hence, are part of the dynamics of the junctional epithelium[7].

HISTOLOGY OF JUNCTIONAL EPITHELIUM:

Junctional epithelium consists of a collar like band of stratified squamous non-keratinizing epithelium.

- ✓ ***Apically - 1 to 3 cells thick***
- ✓ ***Coronally - 15 to 30 cells thick***
- ✓ ***Total thickness - 30 to 100/um***
- ✓ ***Length - 0.25 to 1.35 mm***

It consists of two zones;

1. Basal layer (stratum germinativum) - single cell layer of cuboidal cells.
2. Supra basal layer (equivalent to stratum spinosum) - flattened cells- several layers of cells overlie basal layer.

◙ It is a stratified squamous non-keratinizing epithelium that is made up of 2 strata only, *i.e.*, a basal layer (the stratum basale) and a suprabasal layer (the stratum suprabasale)[7].

◘ The basal cells face the gingival connective tissue. The basal cells and the adjacent 1 to 2 suprabasal cell layers are cuboidal to slightly spindle shaped. All

remaining cells of the suprabasal layer are flat, oriented parallel to the tooth surface, and closely resemble each other[7].

◘ The innermost suprabasal cells (facing the tooth surface) are also called DAT cells (= directly attached to the tooth) (Salonen *et al.*, 1989). They form and maintain the 'internal basal lamina' that faces the tooth surface.

◘ In the interproximal area, the junctional epithelia adjacent to neighboring teeth fuse to form the epithelial lining of the interdental col.

◘ The coronal termination of the junctional epithelium is a free surface and is located either at the bottom of the sulcus, at the gingival margin, or at the interdental col area.

◘ Under pristine conditions, the epithelial seal extends from the cemento-enamel junction to the gingival margin, averaging about 2 mm in height. (Gargiulo *et al.*, 1961). 'Normal' gingiva, however, expresses sub-clinical signs of slight inflammation (Brecx *et al.*, 1987). Therefore, the coronal termination of the junctional epithelium corresponds usually to the bottom of the gingival sulcus.

♦ Basal layer rest on typical lamina propria (Connective tissue), which shows many capillaries & appear to be **more cellular** than other parts of gingiva[4].

♦ The epithelial - connective tissue interface is smooth in healthy gingiva. Junctional epithelium lacks retepegs and is quite thin, tapering at its apical extremity to a layer of only a few cells in depth. Unlike the oral and sulcular epithelium, the junctional epithelium **does not keratinize[4].**

♦ There is a progressive flattening of the cells as they move away from the basal cells toward the tooth surface. The concentration of tonofilaments does not increase between the basal layer and the desquamating surface[2] .The cells produced in the basal layer migrate coronally at the desquamating surface (sulcus) & desquamate the cells.

♦ This desquamating surface is relatively small when compared to proliferative basal cell area. The rate of cellular desquamation in relation to surface area for junctional epithelium is greater than that for sulcular or oral epithelium[4].

♦ This increased flow of cells toward the sulcus bottom may enhance repair and maintenance of junctional epithelium and the integrity of the gingival sulcus[2].

TO DIFFERENTIATE FROM SULCULAR EPITHELIUM:

■ The oral sulcular epithelium is fairly thick and made up entirely of basal and prickle cells of polyhedral shape, whereas the junctional epithelium is thin, containing only a few cell layers, with the cells appearing flattened, as if pressed against the tooth surface[3].

■ The junction between the sulcular and junctional epithelium may usually be identified histological by one or more irregular projections of epithelial pegs or ridges that arise from the apical border of the sulcular epithelium[3].

There are distinct differences between the oral sulcular epithelium, oral epithelium & junctional epithelium[4]:

- The intercellular space (18%) in the junctional epithelium is, relative to the tissue volume, comparatively wider than in oral epithelium.
- The size of the cells in the junctional epithelium is, relative to the tissue volume, larger than in the oral epithelium.
- The number of desmosomes is smaller in the junctional epithelium than in the oral epithelium (4 times less).
- There are fewer intercellular junctions in the junctional epithelium than in the oral or sulcular epithelium. This may explain both its susceptibility to tearing during probing and its greater permeability to migrating cells and fluids.
- Have more prominent reticuloendothelial system and golgi apparatus than other surface gingival epithelium

◙ The interface between the JE and the underlying connective tissue is relatively smooth, unlike the condition found in the OGE. Epithelial rete peg formation from the JE (and the OSE) is a condition found only in highly inflamed connective tissue[6].

ZONES OF JUNCTIONAL EPITHELIUM:

- ✓ Apical zone: - Contains fewer hemidesmosomes and cell with germinative characteristics.
- ✓ Middle zone:- area of greatest attachment having large numbers of hemidesmosomes
- ✓ Coronal zone:- area of greatest permeability characterized by numerous intercellular spaces. Some of which directly open into internal basal lamina.

CELLS OF JUNCTIONAL EPITHELIUM: -

■ Have more prominent reticulo endothelial system and golgi apparatus than other surface gingival epithelium. This may suggest that a prominent function of junctional epithelium to synthesize protein & polysaccharides for maintenance of the basal lamina at both connective tissue & tooth surface.

■ Secretory vacuoles occur along the epithelial cell membranes facing the tooth, and the content of these may be the source of a cementing layer observed on the tooth surface. A few clear cells may also be observed.

■ Lysosomal bodies are found in large numbers in junctional epithelial cells. Enzymes contained within these lysosomes participate in the eradication of bacteria (Lange and Schroeder, 1971).

■ The cells of junctional epithelium are surrounded by a coat or glycocalyx, which consist of the projecting carbohydrate portions of glycoproteins, & glycolipids, major parts of which are embedded in plasma membrane.

■ Protein component of glycoprotein is rich in proline & hydroxyproline, which is secreted by epithelial cells binds the junctional epithelium to enamel or cementum.

■ Junctional epithelium is supported by permissive, deep connective tissue which possesses only permissive factors required to maintain the epithelium & lacks instructive influences as in gingival and sulcular epithelium supported by superficial or subepithelial or instructive connective tissue which influences normal maturation of stratified squamous epithelium. Hence junctional epithelium remains immature.

■ This difference in phenotypic expression is important because, by maintaining a degree of immaturity, the functional epithelium can develop hemi desmosomal attachments where its cells come into contact with the tooth surface.

■ Electron microscopic cytochemical studies have shown that the cells of the JE contain a moderately well-developed lysosomal system and participate in the phagocytosis of material from the intercellular space

■ The thinness of the junctional epithelium allows the cells at the tooth surface to be more metabolically active, as there is lesser distance from their nutritional sources via blood vessels in the lamina propria of the connective tissue.

■ In the pristine state certain leukocytes Ex; neutrophils & macrophages, can be seen in the junctional epithelium. Volume of leukocytes decreases in apical direction and **approaches 0** in the most apical portion.

■ Neutrophilic granulocytes (=polymorphonuclear leukocytes or simply neutrophils, PMNs) are found in the central region of the junctional epithelium and near the tooth surface (Schroeder and Listgarten, 1997).

■ In addition, lymphocytes and macrophages reside in and near the basal cell layer (Schroeder, 1973, 1977).

■ Antigen presenting cells and Langerhans and other dendritic cells are present as well (Juhl *et al.*, 1988). The junctional epithelium, particularly its basal cell layers,

is well-innervated by sensory nerve fibers (Byers and Holland, 1977; Byers *et al.*, 1987; Kondo *et al.*, 1992; Maeda *et al.*, 1994).

■ Within junctional epithelium the mononuclear leukocytes are located in more basal layers, while the neutrophilic granulocytes are present primarily in the superficial portions of junctional epithelium.

■ Widened intercellular spaces, show passage of polymorphonuclear leukocytes & monocytes from gingival connective tissue to the gingival sulcus and also permit the ingress of antigens**. Some 3000 neutrophils migrate per minute.** Occasional langerhans cells the most peripheral component of immune system, also occur in junctional epithelium[4].

■ Cathepsins (B, D, and H) and acid phosphatase, both indicative of degradative enzyme activity, have been localized to primary and secondary lysosomal structures in the cells of the JE[6].

■ Similar to sulcular epithelium, junctional epithelium exhibits lower glycolytic enzyme activity than outer epithelium, and it lacks acid phosphatase activity[1].

HEMIDESMOSOMES & BASAL LAMINA:

♦ The basal lamina together with hemidesmosomes (Listgarten, 1966, 1972a; Schroeder, 1969) forms the interface between the tooth surface and the junctional epithelium and is named 'epithelial attachment' (Schroeder and Listgarten, 1977)[7].

♦ Compared with other epithelia, junctional epithelial cells are interconnected by a few desmosomes only, and occasionally by gap junctions (Schroeder, 1969, 1981; Schroeder and Münzel-Pedrazzoli, 1970; Schroeder and Listgarten, 1977; Yamasaki *et al.*, 1979; Saito *et al.*, 1981; Sasaki *et al.*, 1981; Hashimoto *et al.*, 1986)[7].

♦ The attachment of the junctional epithelium to the tooth is mediated through an ultramicroscopic mechanism defined as the epithelial attachment apparatus. It consists of hemidesmosomes at the plasma membrane of the cells directly attached to the tooth (DAT cells) and a basal lamina-like extracellular matrix, termed the internal basal lamina, on the tooth surface[9].

♦ The components of the internal basal lamina are synthesized by the DAT cells in the absence of the immediate vicinity of connective tissue. Internal basal lamina proteins include laminin and type VIII collagen[9].

Basement membranes are thought to play roles in;

- ✓ compartmentalization (physical barrier function),
- ✓ filtration (selective permeability barrier function or molecular sieve function),
- ✓ cell polarization, migration, adhesion, and differentiation.

They usually consist of a lamina lucida (also known as the lamina rara), a lamina densa, and a lamina fibroreticularis (also known as the sub-basal lamina).

THE BASAL LAMINA:

Ultra structural investigations have revealed a basal lamina between the junctional epithelium & the tooth surface, which is often regarded as evidence of an organic union between epithelium and tooth[4].

The junctional epithelium is the only gingival epithelium with two distinct basal laminas. It has a basal lamina on each surface[2].

External basal lamina:

This basal lamina mediates the attachment of the junctional epithelium to the connective tissue of the junctional epithelium.

Internal Basal Lamina

This attaches the junctional epithelium to the tooth surface.

The 2 zones of basal lamina are the

- ✓ Lamina lucida (electron lucent zone) &
- ✓ The lamina densa (electron dense zone).

Electron dense zone is between junctional epithelium & enamel, This zone has anchoring fibrils on the connective tissue side, but absent on the enamel side.

Internal basal lamina:

◙ It lacks most of the common basement membrane components such as collagen types IV and VII, most laminin isoforms, perlecan, and a lamina fibroreticularis (Salonen and Santti, 1985; Kogaya *et al.*, 1989; Sawada *et al.*, 1990; Salonen *et al.*, 1991; Oyarzun-Droguett, 1992; Hormia *et al.*, 2001)[7].

◙ Laminin-5, however, appears to be expressed in the internal basal lamina but not in the external basement membrane of the junctional epithelium, at least in rats (Oksonen *et al.*, 2001)[7].

◙ The internal basal lamina is approximately **three times thicker** than the external basal lamina[6].

◙ The internal basal lamina contains glycoproteins, laminin, and proteoglycans.

◙ Attempts to localize collagen type IV in this structure have been unsuccessful.

◙ Cells in contact with the internal basal lamina express the integrin, a laminin receptor. The cells in contact with the internal basal lamina contain a relatively well-developed rough endoplasmic reticulum and numerous Golgi components.

◙ Studies of cellular utilization of tritiated thymidine indicate

that the cells in contact with the tooth surface are capable of proliferation and thus could contribute to regeneration of the JE[6].

External basal lamina:

◘ The external basal lamina contains collagen type IV, heparan sulfate proteoglycan, laminin, and fibronectin.

◘ Anchoring fibrils are less prominent in the connective tissue below the JE than they are in the OGE.

Thus the interface between the junctional epithelium and the enamel is structurally is very similar to the epithelium connective tissue interface, which means that the junctional epithelium is not only in contact with the enamel but is actually physically attached to the tooth via hemidesmosomes

MICROSTRUCTURE OF BASAL LAMINA[7]:

● The width of the basal lamina is reported to be in the vicinity of 800A to 1200A. Its components, the lamina densa and lamina lucida, are not always evident, particularly in some decalcified preparations.

● **Stern** defined the ***lamina lucida,*** ~400A, as the structure between the outer leaflet of the epithelial cell membrane and the lamina densa.

● **Kobayashi et al**. described a third lamina, the ***sublamina lucida*** (120 ± 20A), between the tooth and lamina densa. They defined the lamina lucida (140 ± 30A) as extending from the peripheral density of the hemidesmosome to the lamina densa.

Kobayashi et al. viewed the sub-lamina lucida as such a "space" created by an interplay of forces between the lamina densa and the tooth, thus having an important

role in adhesion. Frank and Cimisoni and Stern implied that the lamina lucida plays the important role.

● The ***lamina densa*** of various epithelial-connective tissue interfaces has a proteinaceous composition incorporating collagenous elements.

● It appears to function as a fibrillar attachment. Fine fibrils extend to it from the basal cell plasma membrane. Special fibrils extend to it from the connective tissue.

● Kobayashi et al. described similar filaments extending to the lamina densa of the junctional epithelium.

HEMIDESMOSOMES:

■ The hemidesmosomes are closer together along the tooth surface than along the epithelial connective tissue junction[3].

■ Since there is a higher than normal density of hemidesmosomes on the cell surfaces contacting the tooth, it appears that at least some of these hemidesmosomes have been formed at the contact interface rather than being previously disconnected desmosomes[3].

The hemidesmosomes consist of an attachment plaque associated with cytokeratin filaments and the sub-basal dense plate, which is extracellularly located in the lamina lucida[7].

■ Attachment consists of thickenings of the inner leaflet of the plasma membrane called the attachment plaque. Fine filaments were observed coursing through the lamina densa & lamina lucida & into the hemidesmosomes, which combined them into a unit.

■ Sabag & associates found 4 hemidesmosomes per micron in the coronal zone, & 2 per micron in the apical zone of human teeth.

■ Those in the coronal area were thick & well developed, whereas those in the apical zone were thin & not well developed. When the junctional epithelium was on

cementum and the surface was highly irregular more hemidesmosomes upto 8 per micron were seen.

● *Recent data suggest that the hemidesmosomes may also act as specific sites of signal transduction and, thus, participate in regulation of gene expression, cell proliferation and cell differentiation. The intracellular part of hemidesmosomes consists of at least two distinct proteins, the 230kDa bullous pemphigoid antigen (BP230) and plectin, which is a high molecular weight cytomatrix protein*[9].

ULTRASTRUCTURAL HISTOCHEMICAL STAINS:

◘ Ultrastructural histochemical stains, phosphotungstic acid (PTA), periodic acid silver methenamine (PA Silver), and periodic acid-thiosemicarbazide-silver methenamine (PA-TSC-Silver) demonstrate that the basal lamina contains glycoproteins (neutral mucopolysaccharides), supporting earlier light microscopic findings.

◘ The cuticle does not stain and thus doubt is cast on its possible derivation from basal lamina.

◘ Isolating the junctional material on the tooth surface by using sodium deoxycholate to remove the epithelial cells is a promising tool. Initial ultrastructural studies reveal that the residual material is granular and varies in thickness between 90 to 370A.

PERMEABILITY OF JUNCTIONAL EPITHELIUM:

♦ The chief barrier to passage of substances larger than 100 kDa is provided by the external basal lamina.

♦ Because of the absence of an effective permeability barrier among the cells of the JE, it provides an open pathway for the penetration of bacterial antigens, lipopolysac-charides (LPSs), and enzymes from the sulcus to the connective tissue.

♦ Sulcular fluid, a protein-rich fluid derived from transudation of serum and extracellular fluid, flows in an outward direction through the JE. This fluid contains antibodies, complement, and enzymes that form an antibacterial defense system.

Permeability of junctional epithelium is due to

- ✓ Lower desmosomal density,
- ✓ Few tight junctions,
- ✓ Minimal cytoplasmic filaments[4].
- ✓ Absence of membrane coating granules which consists of lipid or glycolipid, which is present or discharged from cells in the middle layers of oral epithelium, Cells of the JE show no signs of synthesis of membrane-coating granules, a finding that agrees with the fact that the JE is highly permeable to water-soluble substances[6].
- ✓ The parallel orientation of the cells to the tooth surface and the lack of a keratinized layer at the desquamative surface of the junctional epithelium also contribute to the relatively high permeability[2].

■ It was possible to trace horseradish peroxidase antigen in the JE, gingival connective tissue, and cervical lymph nodes at various times after a challenge dose was applied to the coronal area of the gingival sulcus[6].

→ **Within minutes**, the antigen gained access to the intercellular spaces of the JE, and

→ by **1 hour** it was cleared from the gingival connective tissue by macrophages and lymphatics.

→ Within **3 to 5 days**, mature plasma cells producing anti-horseradish peroxidase antibodies were present in the germinal centers of the cervical lymph nodes.

■ The JE also serves as the primary pathway for transmigration of PMNs into the sulcus. In general, there appears to be an inverse relationship between the numbers of infiltrating PMNs and epithelial cell-to-cell junctions[6].

♦ Inflammatory cells and fluid originating from local blood vessels pass through the junctional epithelium into the sulcus.

♦ Inflammatory cell infiltration of the epithelium tends to undermine its structural integrity.

♦ The low cohesive forces between the junctional epithelial cells, together with repeated traumatic injury of the coronal portion of this epithelium, lead to frequent tears that are rapidly repaired because of the rapid migration rate of the epithelium[2].

KERATIN EXPRESSION IN JUNCTIONAL EPITHELIUM:

◘ Morphologic characteristics of junctional epithelium are indicative of a immature undifferentiated epithelium, which is confirmed by the analysis of its constituent keratins & surface carbohydrate. The intermediate filaments of epithelial cells consist of keratins, which is a multigene family of proteins. These keratins are identified using immunocytochemistry[4].

♦ According to Tencate junctional epithelium consists of keratin 19, 8, 18 & blood group marker N, which is found in basal cells of sulcular and gingival epithelium and this is the only carbohydrate marker found in junctional epithelium. This indicates lowest level of cell differentiation[5].

♦ Study by **I.C.Mackenzie et al** (1991) reported that junctional epithelium strongly expresses Keratin 5, 14, 19 which is confirmed by previous observations but differ in indicating stronger expression of K 13 than previously described.

Frequent expression of K. 8 & 18, the keratin pair typical of simple epithelium.

♦ K 19, which was described as a marker of simple epithelia, is frequently expressed by the basal cells of stratifying mucosal epithelia. Now it is known to be more closely related to keratins of stratifying epithelia than those of simple epithelia.

♦ **Caranza & Neumann** have reported that junctional epithelium expresses K 19 (which is absent in keratinized epithelia) & stratification specific cytokeratins K 5 & K 14[1].

♦**Morgan et al** reported that reactions to demonstrate K 4 & K 13 reveal a sudden change between sulcular & junctional epithelium. Because junctional area being the only stratified non keratinized epithelium in the oral cavity that does not synthesize these specific polypeptides.

♦ Junctional epithelium also lacks proliferation specific K 6 & 16 which is usually linked to highly proliferative epithelia, although the turn over of cells is very high.

♦ The lack of K4 in JE marks the boundary between it and the OSE. The boundary between OSE and OGE is not sharply defined by keratin types, because there is some overlap of the suprabasal cell types along the crest of the gingiva.

ADHESION OF JUNCTION EPITHELIUM:

● Whatever the nature of the attractive forces, cells of the junctional epithelium seems to be more adherent to the tooth surface than to one another, because if the marginal gingiva is pulled away from the tooth, the tear occurs within the junctional epithelium and some cells remain attached to the enamel

♦ Obstacle to understand attachment mechanism is that the enamel surface in this region is often covered by a cuticle (unmineralized enamel matrix) or even afibrillar cementum.

♦ The possibilities could be that the cells of junctional epithelium are stimulated to divide by almost invariable inflammatory infiltrate in the subjacent connective tissue or by bacterial mitogens seeping from the gingival sulcus.

♦ Data have also shown that the basal lamina of junctional epithelium resembles that of endothelial & epithelial cells in its laminin content, but junctional epithelium lacks type IV collagen in its internal basal lamina.

These findings indicate that the cells of junctional epithelium are involved in the production of laminin & play a key role in the adhesion mechanism.

♦ **M. Hormia et al** (1998) have shown laminin-5 as a major component of the internal basal lamina & is secreted by epithelial cells at the **epithelium tooth** interface, in both rodents & human tissue and is deposited in the internal basal lamina between epithelium and the tooth.

♦ Using in situ hybridization, they have shown that the cells of junctional epithelium express the LAMC2 gene of laminin-5, which is less prominent in other parts of gingival epithelium[4].

♦ *The a6b4 integrin plays an important role in the interaction of epithelial cells with the extracellular matrix. This interaction utilizes the intracellular plectin connected through the b4-domain of the integrin to laminin-5 (ligand for the a6b4 integrin) in the internal basal lamina. In general, the interaction between the different components of the extracellular matrix and the cell surface molecules linked to the intracellular cytoskeleton is fundamental for cell adhesion, cell motility, synthetic capacity, tissue stability, regeneration and responses to external signals*[9].

DYNAMIC ASPECTS OF THE JUNCTIONAL EPITHELIUM[7]:

◘ The junctional epithelium in primates is known for its high cellular turnover (Skougaard, 1965, 1970; Demetriou and Ramfjord, 1972).

◘ While cell mitosis occurs in the basal and possibly also in some DAT cells (Salonen, 1994), Thus, junctional epithelial cells migrate in the coronal direction toward the free surface, where they desquamate.

◘ Since the surface area occupied by the basal cells is much greater than that of the sulcus bottom, exfoliation must occur at an extremely high rate (Löe and Karring, 1969; Listgarten, 1972b).

◘ Also, the DAT cells are said to migrate toward the sulcus bottom. Since the DAT cells are connected to the basal lamina *via* hemidesmosomes, a remodeling of the epithelial attachment must occur. Thus, the epithelial attachment normally is not static but dynamic.

◘ Junctional epithelium has fast turn over rate, being replaced in a matter of days. This rapid turn over allows insufficient time for its cells to produce the materials needed for a permeability barrier (MCG's, intercellular junctions)[4].

◘ In the absence of clinical signs of inflammation, approximately 30,000 PMNs migrate *per* minute through the junctional epithelia of all human teeth into the oral cavity (Schiött and Löe, 1970).

◘ The tissue fluid transports a variety of molecules through the junctional epithelium to the bottom of the gingival sulcus[7].

◘ Previously it was thought that only epithelial cells facing the external basal lamina were rapidly dividing. However, recent evidence indicates that a significant number of the DAT cells are, like the basal cells along the connective tissue, capable of synthesizing DNA, which demonstrates their mitotic activity. At the coronal part of the junctional epithelium, the DAT cells typically express a high density of transferrin receptors, which supports the idea of their active metabolism and high turnover.

The findings suggest that the DAT cells have a more important role in tissue dynamics and reparative capacity of the junctional epithelium than has previously been thought[9].

REGENERATION OF THE JUNCTIONAL EPITHELIUM[6]:

♦ At least *2* weeks are needed for regeneration of a complete JE. This new JE will extend apically until it encounters a firm collagen fiber attachment to cementum.

♦ Differences in cell proliferation rates among the three regions of gingival epithelium may be the result of their responsiveness to the growth-inhibitory effect of TGF-p. The cells of OGE express receptors for TGF-p, while the more rapidly proliferating cells of the JE have fewer TGF-p receptors.

♦ Another factor that may account for different proliferation rates is epidermal growth factor (EOF). Cells of healthy JE contain high levels of epidermal growth factor (EOF) and express EGF receptors. Under the same conditions, the OGE and the OSE are negative for EGF and EGF receptor.

♦ Following surgical removal of the entire gingiva, a new junctional epithelium forms from adjacent oral epithelium by migration of cells from the cut epithelial edge toward the tooth surface[6].

♦ The application of gingivectomy techniques would completely remove the junctional epithelium. Subsequently, the formation of a new junctional epithelium must occur from basal cells of the oral gingival epithelium (Listgarten, 1967; Innes, 1970; Frank *et al.*, 1972; Listgarten and Ellegaard, 1973; Braga and Squier, 1980).

♦ In humans, a new junctional epithelium after gingivectomy may form within 20 days (Listgarten, 1972; Schroeder and Listgarten, 1977)[7].

♦ Densely packed collagen bundles are anchored to the acellular extrinsic fiber cementum just below the terminal point of the JE. These collagen bundles form the

connective tissue attachment. The stability of this connective tissue attachment is a key factor in limiting the apical migration of the JE.

♦ Resorption of collagen along the root surface beneath the JE removes a barrier to epithelial migration. Collagenolytic enzymes involved in the destruction of the connective tissue attachment may originate from fibroblasts, macrophages, and neutrophils located next to the JE.

♦ The leading edge of a migrating JE have no internal or external basal lamina and no hemidesmosomes. They resemble the epithelial cells observed at a wound edge.At a distance apical to the leading edge, the epithelial cells attach to mineralized cementum by developing a basal lamina and forming numerous hemidesrnosomes. This attachment appears similar to that formed on enamel[6].

WOUND HEALING:

◙ Surgical removal or detachment of the gingiva from the tooth is followed by formation of a new junctional epithelium and epithelial attachment.

◙ During healing after gingivectomy, hemidesmosomes appear before the lamina densa forms.

◙ It should be noted that there are less or no anchoring fibrils at the basal lamina abutting the tooth. Tonofilaments do not form clearly evident plaque insertions in the junctional epithelium.

◙ Wounds produced in teeth of marmosets shows complete restoration of the epithelial attachment is evident in 5 days.

◙ Observations made in wound healing studies at longer intervals show normal junctional structure .In all instances the presumptive evidence is that the regenerating tissues are derived adjacent gingival epithelial basal cells.

EXPRESSION OF VARIOUS MOLECULES AND THEIR FUNCTIONS[7]:

● Junctional epithelial cells express numerous cell adhesion molecules (CAMs), such as integrins and cadherins The expression of the integrin subunits (Hormia *et al.*, 1992, 2001; Thorup *et al.*, 1997; Gurses *et al.*, 1999)

● Cadherins are responsible for tight contact between cells (Ivanov *et al.*, 2001; Juliano, 2002).

● An analysis of the expression of the carcino-embryonic Ag-related cell adhesion molecule 1 (CEACAM1) a transmembrane cell-adhesion molecule that is expressed on leukocytes, epithelia, and blood vessel endothelia. Thus, the dynamic cohesion of the junctional epithelial cells may, to a large extent, be mediated by CEACAM1 (Heymann *et al.*, 2001)[7].

Expression of Cell Surface Adhesion Molecules in Gingiva:

● There is some experimental evidence that the special features of the junctional epithelium are controlled by an inductive stimulus from the connective tissue.

● Inductive mechanisms of this nature are responsible for maintaining the individual characteristics of integumental epithelium and are referred to as epithelial-mesenchymal interactions[4].

● Integrins are a large family of transmembrane glycoproteins, which serve to attach cells to a large number of extracellular matrix ligands such as fibronectin, laminin, vitronectin, tenascin, and osteopontin.

● Calcium binding surface adhesion molecules, the cadherins, are components of desmosomes and adherens junctions

● Another class of cell surface adhesion molecules that is of significance to the biology of gingival tissues is the immunoglobulin class, of which intercellular adhesion molecule 1 (ICAM-1), endothelial leukocyte adhesion molecule 1 (ELAM-1),

and vascular cell adhesion molecule 1 are known to increase in gingiva during inflammation[6].

● Intercellular adhesion molecule 1 is present on the cell membrane of JE cells and adjacent fibroblasts and endothelial cells but absent from healthy OSE and OGE and adjacent blood vessels.

●Another adhesion factor important for leukocyte transmigration in inflammatory lesions is ELAM-1(Endothelial leukocyte adhesion molecule 1) has been localized on blood vessels of gingivitis lesions . This molecule is expressed on endothelial cells that have been activated by cytokines such as TNF-a, IL-1, and bacterial lipopolysaccharides[6].

●In this context, the high expression of interleukin-8 (IL-8), a chemotactic cytokine, in the coronal-most cells of the junctional epithelium may be an additional mechanism of routing PMNs toward the bacterial challenge (Tonetti *et al.*, 1994, 1998)[7].

●Other cytokines such as interleukin-1 (IL-1), and tumor necrosis factor are strongly expressed in the coronal half of the junctional epithelium (Miyauchi *et al.*, 2001)

●The active role the junctional epithelium plays in the innate host defense is also demonstrated by the production of natural antimicrobial peptides and proteins in response to the bacterial challenge (Dale, 2002).

● Antimicrobial molecules that may contribute to periodontal health include the defensins, the cathelicidin family members (LL-37), and calprotectin.

● Hence, from a clinical point of view, it has to be realized that the junctional epithelium represents a key mechanism in host-parasite interactions, since it actively participates in the host defense mechanism rather than simply providing an attachment to the tooth surface[7].

● The epithelial attachment is capable of being formed on enamel, cementum, afibrillar cementum and cuticle.

LOCATIONS AND FUNCTIONS OF MOLECULAR FACTORS ASSOCIATED WITH THE JUNCTIONAL EPITHELIUM:

MOLECULAR FACTORS	LOCATION WITHIN JUNCTIONAL EPITHELIUM	SUGGESTED FUNCTION
Cell Adhesion Molecules (CAMs)		
Integrins	*Cell membrane of junctional epithelial cells*	*Mediate cell-matrix and cell-cell interactions*
Epithelial cadherin (E-cadherin)	*Epithelial intercellular junctions*	*Critical in intercellular adhesion and thus crucial for maintaining structural integrity*
Carcino-embryonic Ag-related cell adhesion molecule 1 (CEACAM1)	*Cell membranes of leukocytes and junctional epithelial cells*	*Adhesion between epithelial cell : contributes to guidance of PMNs through the junctional Epithelium;participates in the regulation of cell proliferation, stim ulation, and co-*

		regulation of activated T-cells; the cell receptor for certain bacteria
Intercellular adhesion	Cell membrane of junctional epithelial cells	Mediates cell-cell interactions in inflammatory reactions; guiding PMNs toward the sulcus bottom
Lymphocyte function antigen-3 (LFA-3)	Cell membrane of junctional epithelial cells	Mediates cell-cell interactions in inflammatory reactions; controls leukocyte migration to inflammatory sites
Cytokines/Chemokines		
Interleukin-8 (Il-8)	In junctional epithelial cells near the sulcus bottom	Chemotaxis; guiding PMNs toward the sulcus bottom
Interleukin-1alpha (Il-1alpha) Interleukin-1beta (Il-	In junctional epithelial cells and macro-phages in the coronal	Pro-inflammatory cytokines that contribute to the innate immune

1beta) Tumor necrosis factor-alpha (TNF-alpha)	portion of the junctional epithelium	defense
Cell-membrane-associated Blood-group-specific Carbohydrates		
N-acetyllactosamine	Cell membrane of junctional epithelial cells	Indicates a low level of cell differentiation
Growth Factors and Corresponding Receptors		
Epidermal growth factor (EGF)	In junctional epithelial cells	Mitogen that participates in epithelial growth,differentiation, and wound healing
Epidermal growth factor receptor (EGFR)	Cell membrane of junctional epithelial cells	Signal transduction
Proteases		
Tissue plasminogen activator (t-PA)	In junctional epithelial cells	Serine protease that converts plasminogen into plasmin, which in turn degrades extracellular matrix proteins and activates matrix metalloproteinases

Matrix metalloproteinase-7 (MMP-7 or matrilysin)	In suprabasal junctional epithelial cells	Proteolytic degradation of the extracellular matrix
Natural antimicrobial peptides and proteins		
Alpha defensins	In PMNs and gingival crevicular fluid	PMN-produced antimicrobial substances that contribute to the innate immune defense
Cathelicidin LL-37	In junctional epithelial and inflammatory cells	Epithelially produced antimicrobial substances that contribute to innate host defense
Human beta defensin-1 (hBD-1) Human beta defensin-2 (hBD-2)	Weak expression in junctional epithelial cells	Epithelially produced antimicrobial substances that contribute to innate host defense

JUNCTIONAL EPITHELIUM IN THE ANTIMICROBIAL DEFENSE[9]:

- Even though junctional epithelial cell layers provide a barrier against bacteria many bacterial substances, such as

lipopolysaccharide, pass easily through the epithelium but have only limited access through the external basal lamina into the connective tissue.

- Both the internal and external basal laminas act as barriers against infective agents. Rapid turnover, as such, is an important factor.

- There is increasing evidence indicating that several specific antimicrobial defense systems exist in the oral mucosa. Many epithelial cell types, including junctional epithelium, have been found to contain enzyme-rich lysosomes. Their fusion with plasma membrane is triggered by elevation of the intracellular calcium concentration.

- The role of these enzymes in the antibacterial mechanism has not yet been studied. Recently, it has been found that the junctional epithelial cells lateral to DAT cells produce matrilysin (matrix metalloproteinase-7).

◘ Leukocytes, especially the polymorphonuclear leukocytes that migrate through the junctional epithelium, comprise probably the most important defense mechanism at the gingival margin. The cells respond actively to bacterial infection by producing cell adhesion molecules (intercellular adhesion molecule- 1) and chemotactic substances (chemokines such as C5a, leukotriene B4, lymphocyte function-associated antigen-3 and interleukin-8) that facilitate the migration of leukocytes through the junctional epithelium.

◘ Recently, it has been suggested that supplementary to system-derived antibodies and antibodies produced locally by plasma cells, the junctional epithelial cells may also have a secretory function

SHIFT OF DENTO GINGIVAL JUNCTION:

■ It has already been indicated that within the connective tissue supporting the junction inflammatory changes exist.

■ This means that with time, there is often a gradual loss of the supporting tissue of the tooth and a subsequent apical migration of the dento gingival junction.

■ The junction thus passes on to the cemental surface of the root with advancing age. This apical migration has been called passive eruption, because it results in an increase in the length of the clinical crown of the tooth.

■ When the tooth has reached the occlusal plane, the gingival sulcus is located approximately over the gingival third of the crown. The junctional epithelium extends from this point apically to the region of the cervix. Apical to this point and along the entire circumference of the root, the Sharpey's fibers anchored into the cementum attach the tooth to the bone. This is the ideal arrangement of the periodontium[4].

ACTIVE & PASSIVE ERUPTION OR EXPOSURE:

♦ The gradual gingival recession that uncovers the anatomic crown and possibly some of the root surface is known as ***passive eruption*** **or** ***exposure***[2].

♦ Passive eruption is useful in describing various levels of attachment that may occur as the gingiva recedes on to cementum. Although this was originally thought to be a normal physiologic process, it is now recognized to be a as pathologic process[4].

♦ Many investigators, starting with **Gottlieb (1921, 1943)** hold that this state of affairs is merely a transitional stage and that the epithelium, as age progresses is apt to proliferate in an apical direction. In doing so, it establishes new firm union (epithelial attachment) with the cementum surface. This apical shift of the dento gingival junction has been termed ***passive eruption***[4]***.***

♦ The apical shift of the bottom of the gingival sulcus may be accompanied by an increase in sulcus depth. In other instances a shallow sulcus may remain, in which case a recession of the marginal gingiva has taken place concomitantly with the down growth of the epithelium.

♦ **Gottlieb (1943) & others** have considered passive eruption as physiologic process that is continuous throughout life at a rate corresponding to the occlusal movement of the teeth in compensation for attrition.

♦ The latter process is known as ***active eruption***. Active and passive eruptions have been thought to occur simultaneously. The purpose of passive eruption is to keep clinical crown at an adequate length. Basically any apical proliferation of cells of the junctional epithelium along the cementum surface presupposes a breakdown of the upper most Sharpey's fibers[4].

♦ Karring et al (1975) has shown that active eruption may take place without movement of junctional epithelium below the neck of tooth. Thus it gave conclusion that apical shift of the dento gingival junction or passive eruption, does not appear to be a physiologic process[4].

Passive eruption is divided into four stages[4]

1. **First stage:**

→ After the teeth has reached the line of occlusion, the bottom of the gingival sulcus remains in the region of the enamel covered crown and the apical end of the attachment epithelium stays at the cemento enamel junction.

→ This relation persists in primary teeth almost upto 1 year of age before shedding and, in permanent teeth, usually to the age of 20 or 30 years.

2. **Second stage:**

→ The bottom of the gingival sulcus is still on the enamel and the apical end of the attachment epithelium has shifted to the surface of the cementum.

→ The down growth of the attachment epithelium along the cementum is but one facet of the shift of the DGJ. This entails dissolution of the fiber bundles that were anchored in the cervical parts of the cementum, now covered by the epithelium and an apical shift of the gingival and transseptal fibers.

→ The destruction of the fibers may be caused by enzymes formed by the epithelial cells, by plaque metabolites or enzymes, or by immunologic reactions as manifestations of periodontal disease.

→ This stage of tooth exposure may persist to the age of 40 years or later.

3. Third stage:

→ The bottom of the gingival sulcus is at CEJ and epithelium attachment is entirely on the cementum and the enamel-covered crown is fully exposed.

→ This stage in the exposure of a tooth no longer is a passive manifestation. The epithelium shifts gradually along the surface of the tooth and does not remain at the CEJ.

→ This is more or less a continues but slow process as the body's attempt to maintain an intact dentogingival junction against the factors that cause its deterioration.

4. Fourth stage:

→ This stage represents recession of the gingiva. When the entire attachment is on cementum, the gingiva may appear normal, but the process is regarded as pathologic.

→ It may occur without perceptible evidence of inflammatory periodontal disease.

VARIATIONS IN PASSIVE ERUPTION[4]:

- ✓ The rates of crown exposure varies and also recession in different persons. In some cases 4th stage seen at – 20's. In others still in 1st stage or 2nd stage - 50's
- ✓ Rate varies in different teeth of same jaw and on different surfaces of the same tooth.
- ✓ One side may be - first stage - other side - 2nd or even 4th stage.

- ✓ Gradual exposure of tooth makes it necessary to distinguish between anatomic and clinical crowns. (Part of tooth covered by enamel - anatomic crown. Part of tooth exposed in oral cavity - clinical crown).
- ✓ In first and second stages - clinical crown is smaller than anatomic crown.
- ✓ With recession (third stage) enamel covered part of tooth is exposed i.e. clinical crown = anatomic.
- ✓ At fourth stage, because parts of root also has been exposed - clinical crown is larger than anatomic.

MIGRATION OF ATTACHMENT EPITHELIUM[10]:

● Therefore, any structural or molecular changes in the internal basal lamina can potentially influence the vital functions of the DAT cells and contribute to the effectiveness or failure of the junctional epithelial defense or vice versa; changes in the cell metabolism, etc. may affect the internal basal lamina.

● *Bacterial agents may thus indirectly trigger mechanisms that lead to modulation of host cell behavior. Hypothetically, even minor changes in cell metabolism, biosynthetic activity or ability to divide and migrate may eventually lead to degeneration and detachment of the junctional epithelium/DAT cells and allow pathogenic flora to grow on the exposed subgingival tooth surface.*

● The reduced ameloblasts present in the primary junctional epithelium is attached by hemidesmosomes to lamina lucida (an electron lucent zone seen under electron microscope). These cells do not divide, on the other hand, basal cells adjacent

to the tooth do divide and migrate up and along the tooth, desquamating in 4 to 6 days[4].

● In attachment epithelium the cells specialize and synthesize a basal lamina (the epithelial attachment). They then migrate over it, with their attachment being maintained by the hemidesmosomes. In general a cell once specialized neither synthesizes DNA nor divides.

● Oral epithelial cells migrate to gingival surface and keratinize or move toward reduced ameloblasts to which they attach.

● While the reduced ameloblasts are still present, the cells of the oral epithelium join them by forming desmosomes. Here the primary junctional epithelium gradually degenerates and is replaced by secondary junctional epithelium.

● The cells of the oral epithelium contact the tooth surface, there forming hemidesmosomes and a lamina lucida, by means of which the cells attach themselves to the tooth[4].

● At the secondary junctional epithelium, cells of the two tissues are joined by desmosomes and by tight junctions. At the point of fusion of two tissues mitotic activity is increased. Here cells of outer enamel epithelium and possibly stratum intermedium join cells of oral epithelium in forming a locus of proliferation. With complete degeneration of primary attachment epithelium, secondary attachment epithelium contacts enamel and attaches by same mechanism as primary. After sometime, secondary junctional epithelium may be found attaching to both enamel and cementum[4].

THE EPITHELIAL COMPARTMENT OF THE DENTOGINGIVAL JUNCTION AND PERIODONTAL DISEASE[10]:

Morphologic changes of the epithelium in the presence of inflammation include:

- Intercellular edema, evident through widened intercellular spaces.
- Decreased numbers of desmosomes.

- Disruption of the outer (connective-tissue) facing basal lamina .
- Cellular disruptions.

All of these changes are related to pocket formation.

These events are more evident in the junctional epithelium than in the gingival epithelium.

■ Some disruption of the ***basal lamina*** at the epithelio-connective tissue junction occurs. The basal lamina may exhibit decreased or increased thickness, detachment, multilayer formation, etc

■ When the new cells are separated by some distance from the old basal lamina, they develop a new basal lamina. This may result in the formation of two or more layers of the basal lamina.

■ Perforations in the basal lamina which are produced, as inflammatory cells migrate through.

♦ MORE RECENTLY there has been a classification of stages in the pathogenesis of pockets. These stages (initial, early, established and advanced) are related to degree of inflammatory infiltrate[10].

♦ The progression of a contained initial lesion into a destructive lesion is accompanied by a widening of the intercellular space of junctional epithelium.

♦ The widened intercellular spaces, indicative of increased permeability, permit further ingress of plaque antigens, chemotactic substances, toxins, etc. and increased activity of the host response mechanism.

♦ The activity of the antigens and the toxins and the inflammatory response both produce continuous cycles of reciprocal consequences. Eventually the junctional epithelium is disrupted and the periodontal pocket forms.

♦ The epithelial cells are damaged and the continuity of the tissue is interrupted. Inflammatory cells are found in increasing numbers in the junctional epithelium, and in addition to accentuating the opened intercellular space, they may displace the junctional epithelium from the tooth surface.

♦ The border between junctional epithelium and connective tissue is straight in health and contains projections (epithelial pegs or ridges) in disease.

♦ The apparent border between junctional epithelium and the adjacent gingival or sulcular epithelium becomes more marked as the cellular infiltrate in the junctional epithelium increases from 30% to 60%. Then the most coronal cells of the junctional epithelium disintegrate and are lost and the sulcus bottom/junctional epithelium top shifts apically.

THE CONNECTIVE TISSUE COMPARTMENT OF THE DENTOGINGIVAL JUNCTION AND PERIODONTAL DISEASE[10]:

◘ The connective tissue is the primary site of the inflammatory response of periodontal disease. The connective tissue also contributes to epithelio-mesenchymal inductive interactions and to those events based upon such phenomena.

◘ In periodontal disease, the collagen fibrils of the ligament diminish in diameter and the interfibrillar space widens. The gingival fibers are destroyed subjacent to the junctional epithelium, but are first degraded and become less numerous.

◘ As a consequence of the loss of collagen, the apical portion of the junctional epithelium proliferates along the root, extending finger like projection, 2 or 3 cells in thickness.

◘ Migration of junctional epithelium on to root cementum is possible only after dissolution of the upper most Sharpey's fibers. This destruction is effected at the stage where the marginal inflammation has reached into the supra alveolar connective tissue.

FIBROBLAST CHANGES[10]:

◘ The fibroblasts undergo various pathologic alterations; their normal spindle or elongate shape is transformed into a rounded one and they become up to **3 times** as large. Their endoplasmic reticulum and ribosomal arrangement are more random than organized, indicative of a disturbance in collagen synthesis.

◘ The fibroblast has beer shown to be active in collagenolysis via intracellular phagocytosis. The fibroblasts do not appear to be stationary. They are capable of movement. They contain contractile filaments and can form gap junctions with other fibroblasts, suggestive of mobility.

◘ Page and Schroeder indicate that in **the *initial lesion***, the connective tissue is rarely more than 5 to 10% involved. In the ***early lesion*** collagen loss can reach 60 to 70% and most of the fibroblasts appear to be altered.

◘ In the **established lesion** the junctional and sulcular epithelia proliferate into the infiltrated connective tissues and along the root surface. The gingival sulcus deepens and the coronal portion of the junctional epithelium is converted into pocket epithelium.

◘ In the ***advanced lesion*** the fiber bundles of the marginal gingiva lose their characteristic orientation completely, while the transseptal fiber bundles appear to be continuously regenerated farther apically as the lesion extends. Fingerlike projections of pocket epithelium extend deeply into the connective tissue and the junctional epithelium migrates apically.

◘ Another ultrastructural study of established periodontitis in the rat showed that fiber loss takes place below the junctional epithelium.

It can be divided into three zones:

a) complete loss immediately apical to the junctional epithelium,

b) partial loss apical to the zone of complete loss, and

c) a normal-appearing zone apical to that.

◘ In ligature-induced rapidly destructive periodontitis in dogs, the destruction of supra-alveolar connective tissue in the initial phase is not accompanied by complete destruction of the connective tissue attachment (fibers remain attached to cementum) and is not immediately followed by apical migration of the junctional epithelium.

ROLE OF THE JUNCTIONAL EPITHELIUM IN THE INITIATION OF POCKET FORMATION[7]:

◙ A clinically healthy gingiva exhibits microscopic signs of slight inflammation, including the presence of an inflammatory infiltrate of very limited extent (Brecx *et al.*, 1987).

◙ Thus, such inflammatory cells in the subepithelial portion of the lamina propria and in the junctional epithelium itself should be regarded as a part of normal homeostasis and an essential element of the defense system against continuous bacterial challenge (Schroeder and Listgarten, 1997).

◙ Several researchers have attributed pocket formation to a loss of cellular continuity in the coronal most portion of the junctional epithelium (Schluger *et al.*, 1977; Schroeder and Listgarten, 1977). Thus, the initiation of pocket formation may be attributed to the detachment of the DAT cells from the tooth surface or to the development of an intra epithelial split.

◙ It has already been hypothesized that pocket formation is the result of subgingival spreading of bacteria under impaired defense conditions (Schroeder and Attström, 1980).

POCKET FORMATION[10] has been attributed to a loss of cellular continuity in the coronal portion of the junctional epithelium, recalling concepts of **Weski and Euler** who attributed pocket formation to an intraepithelial split.

While loss of cell continuity certainly plays a contributory role, the loss of subepithelial collagen, the lysis of collagen fibers inserting into the cementum, and the breakdown of the basal lamina are the main factors. **The pocket is a result of the subsequent apical reconstitution of the basal lamina below the junctional epithelial cells that have migrated apically. The basal cells attempt to reconstitute a basal lamina over the pathologically altered connective tissue**[10]**.**

♦ Particular attention has been paid to elucidating the mechanisms by which *Actinobacillus actinomycetemcomitans* and *Porphyromonas gingivalis* (*P. gingivalis*), 2 pathogens implicated as major etiological agents in aggressive and chronic periodontitis, adhere to, invade, and replicate in epithelial cells (Lamont *et al.*, 1992, 1995; Sandros *et al.*, 1994; Madianos *et al.*, 1996; Meyer *et al.*, 1997; Njoroge *et al.*, 1997; Deshpande *et al.*, 1998; Huard-Delcourt *et al.*, 1998; Lamont and Jenkinson, 1998; Fives-Taylor *et al.*, 1999; Forng *et al.*, 2000; Quirynen *et al.*, 2001).

♦ Recently, a new effect of gingipains has emerged. It has been shown that gingipains specifically degrade components of the epithelial cell-to-cell junctional complexes (Wang *et al.*, 1999; Katz *et al.*, 2000, 2002; Chen *et al.*, 2001; Hintermann *et al.*, 2002).

♦ Epithelial cells challenged **by** *P. gingivalis* exhibit proteolysis of focal contact components, adherens junction proteins, and adhesion signaling molecules (Hintermann *et al.*, 2002).

♦ Furthermore, epithelial cells exposed to *P. gingivalis*, or to proteinases derived from it, showed reduced adhesion to extracellular matrices, changes in morphology, impaired motility, and apoptosis.

♦ The recent observation that gingipains may also disturb the ICAM-1-dependent adhesion of PMNs to oral epithelial cells, an immune evasion mechanism **by** *P.gingivalis*, points to the importance of these molecules for the disintegration of the junctional epithelium (Tada *et al.*, 2003).

JUNCTIONAL EPITHELIUM ADJACENT TO ORAL IMPLANTS[11]:

♦ They also found that there was less peri-implant pocketing at implants surrounded by attached gingiva. Schroeder et al suggested that a keratinized gingival collar was more likely to be associated with a fibrous type of "attachment" to the implant (with textured surface implants) which can stabilize the peri-implant permucosal tissues against trauma[11].

♦ Structurally, the periimplant epithelium closely resembles the junctional epithelium around teeth (Berglundh *et al.*, 1991; Listgarten *et al.*, 1991; Buser *et al.*, 1992; Listgarten, 1996; Koka, 1998; Cochran, 2000), although dissimilarities have also been reported (Inoue *et al.*, 1997; Ikeda *et al.*, 2000, 2002; Fujiseki *et al.*, 2003;

Shimono *et al.*, 2003)[7].

♦ There is also evidence that several of the mentioned marker molecules involved in the defense mechanisms against the bacterial challenge are also expressed in the peri-implant epithelium. (Schmid *et al.*, 1992).

♦ Kurashina et al described noninflamed and inflamed peri-sulcular tissue at dense hydroxyapatite (HA) implants in dogs, which closely parallels that observed about natural teeth in the same animal model[11]:

1. ***Noninflamed:***

◙ In the connective tissue of the gingiva, a limited infiltration of inflammatory cells was noted.

◙ Outside this area, numerous bundles of collagen fibers were seen and many of these fibers terminated perpendicularly to the interface with the implants, resulting in a saw-toothed pattern (Sharpey's fibers).

◙ The epithelium on a lower level, adjoining the implant surface, was 2 to 5 cells thick. There was no cell differentiation between the subsequent superficial layers, no keratinization, and few or no papillae.

2. ***Inflamed:***

● There were multiple bone resorptions at the alveolar bone crest. In some sections, islands of bone were seen lying at the interface with the implant, just above the alveolar bone.

● At the supra-alveolar level the gingival connective tissue showed a large field of inflammatory cells and disappearance of collagen fibers.

● Epithelial downgrowth lined the implant sulcus. The lowest level was always above the alveolar bone.

"EPITHELIAL ATTACHMENT" HISTOLOGY[11]:

● At the base of the gingival crevice of natural teeth, cells of the attachment epithelium have been characterized as being larger, with wider intercellular spaces and

fewer desmosomes than the cells lining the gingival crevice. At the tooth surface, a basal lamina is secreted by the junctional epithelial cells, which is composed of three distinct layers: the lamina lucida, lamina densa, and sublamina lucida. The JE cell membrane approximating the basal lamina contains electron-dense plaques (hemidesmosomes), which have been shown to be associated with epithelial attachment to underlying connective tissue or to substrate. In addition, various protinaceous cuticles are often interposed between the basal lamina and tooth surface.

- Significant debate has transpired over the histology at the dental implant—permucosal penetration site. Listgarten and Lai were the first to report hemidesmosomes associated with implant material (resin).

James and Schultz, who were also early proponents of the hemidesmosome-implant relationship, observed hemidesmosomes associated with vitallium implants in monkeys. However, many investigators refused to accept the early reports of hemidesmosomes in association with implants.

- Older histologic sectioning techniques made identification **of hemidesmosomes** difficult. However, after the development of new histologic techniques such as cryofracture and oxygen plasma surface etching of poly(methyl methacrylate),hemidesmosomes became more accurately defined.

- Schroeder et al reported functional hemidesmosomes and basal lamina on titanium-sprayed (textured surface) implants in monkeys, stating that:

As the implant surface particles protruded into the basal lamina, the intracytoplasmic tonofilaments, which are usually parallel to the cell axis, were rearranged to a position perpendicular to the surface of the inward protruding implant possibly indicating that functional loads imparted to the implant are partially taken up by the epithelial cells.

- Many of these studies provided excellent electron microphotographs of the hemidesmosome-implant phenomenon.

● More fundamental is the question of why migration of epithelial cells does not seem to occur in the osseointegrated implants?

● Gould reasoned that contact inhibition from the underlying connective tissue was responsible. Van Steenberghe agreed with this theory of contact inhibition but felt that the contact inhibition was achieved from the mature collagen seal at bone level or a surface irregularity of the implant.

● Whether hemidesmosomes at epithelial-implant junctions are comparable to their counterpart in the natural dentition is yet unresolved. However, because the evidence for implant-epithelial adhesion predominates in the literature, one is led to believe in its existence and probable function.

FEATURE	TOOTH	IMPLANT
Sulcular epithelium	+	+
Junctional epithelium	+	+
Basal lamina	+	+
Hemidesmosomes	+	+
Glycoprotein adhesion	+	+
Connective tissue fiber insertion	+	-

SUMMARY[10]:

The tissues of Dentogingival junction are dynamic rather than static. Even when they are pathologic, they can be reconstituted repair. Both their cellular and extracellular components exhibit a high rate of turnover. Some of the cells are specialized for specific functions, such as attachment formation, and do not generate additional cells, but generative pools are always nearby. The cells are capable of

movement and of positional change. The junctional epithelium can advance and retract. The cuticle width is alterable. The entire tissue is capable of regeneration after wounding. This dynamic group of tissues is well adapted for the healing of direct injuries produced during mastication.

REFERENCES:

1. Clinical Periodontology – 10th Ed. Carranza, Takei, W.B. saunders.
2. Periodontics - 6th Ed. Daniel A. Grant, Mosby company.
3. Periodontology and Periodontics - Ramfjord, Ash, AITBS pub.
4. Orban's Oral Histology and Embryology - 11th Ed . S.N. Bhaskar, CBS publishers.
5. Oral Histology- Development, structure & Function. 6th Ed, Richard TenCate, Mosby company.
6. Oral cells and Tissues - P.R. Garant, Quintessence books.

7. The Junctional epithelium; from Health to Disease – D.D. Bosshardt, N.P.Lang
JDR 84 (1);2005:9-20
8. Junctional Epithelium; from strength to defense – Schroeder, Listgarten
JDR 82(3);2003:158-161
9. Structure and function of tooth epithelial interface in health and disease
Perio 2000;31; 2003:12-31
10. Current Concepts of the Dentogingival Junction: - Irving B. stern
J.Periodontol 52;9:1981
11. The Peri-implant sulcus - Baumann et al
Int. J.Oral & Maxillfacial Implants 8;1993 :273-280
12. Clinical Periodontology - 6th Ed., Carranza, W.B. Saunders.

FIGURE REFERENCES:

1. Dental Embryology, Histology, and Anatomy – 2nd Ed. Mary Bath et al, Elsevier Saunders
2. Lab Manual of Normal oral histology – Holliston.L. Riviere, Quintessence pub.
3. Color Atlas of Oral Anatomy, Histology and Embryology – 3rd Ed.
B.k.B.Berkovitz et al, Mosby company
4. Tencate Oral Histology – 6th Ed. Antoni Nanci, Elsevier
5. Oral Cells and Tissues – P.R.Garant, Quintessence books
6. Periodontology and Periodontics - Ramfjord, Ash, AITBS pub.

7. Periodontics, Medicine, surgery and Implants – Louis F Rose, Brian, Mealey, Elsevier mosby.
8. Periodontics – Shantipriya reddy, Jaypee pub.
9. Periodontics - 6th Ed. Daniel A. Grant, Mosby company.
10. Clinical Periodontology – 6th Ed. Carranza, W.B.Saunders
11. Essentials of Oral histology, and Embryology – 2nd Ed. James K.Avery
12. Structure and function of tooth epithelial interface in health and disease Perio 2000;31;2003:12-31
13. Color atlas of dental medicine; Periodontology – 3rd Ed, Wolf, Klaus, Hassel, Thieme publications