Periodontology- fourth stage

First semester-Microbiology of dental plaque
Lec-6-Part-1

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- Composition of dental plaque.
- Classification of dental plaque.
- Microscopic structure of dental plaque.
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- Communication Between Biofilm Bacteria.

Dental plaque

- **Dental plaque*:*** is defined clinically as a structured, resilient yellow-grayish substance that adheres tenaciously to the intraoral hard surfaces, including removable and fixed restorations.

- ✓ **Plaque can thus be differentiated from other deposits that may be found on the tooth surface, such as materia alba and calculus.**

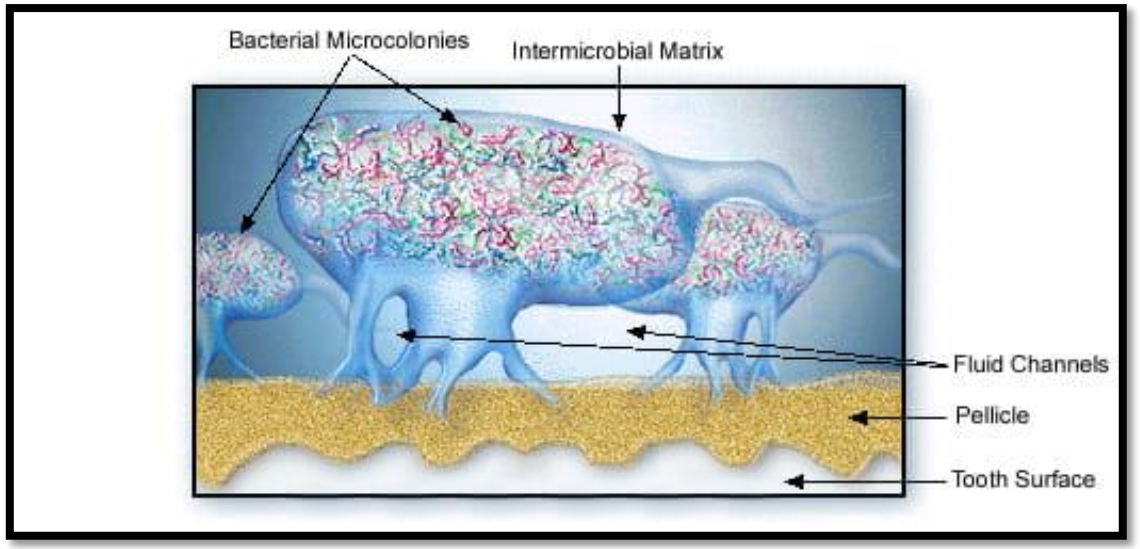
- **Materia alba*:*** refers to soft accumulations of bacteria, food matter, and tissue cells that lack the organized structure of dental plaque and that are easily displaced with a water spray.

- **Dental Calculus*:*** is a hard deposit that forms via the mineralization of dental plaque and that is generally covered by a layer of unmineralized plaque.

Materia Alba	Dental Plaque	Calculus
White, cheese like accumulation	Resilient clear to yellow-grayish substance	Hard deposit that forms via the mineralization of dental plaque
Soft accumulation of salivary proteins, some bacteria, many desquamated epithelial cells, and occasional disintegrating food debris	Primarily composed of bacteria in a matrix of salivary glycoproteins and extracellular polysaccharides	Generally covered by a layer of unmineralized dental plaque
Lacks an organized structure and is therefore not as complex as dental plaque	Considered to be a biofilm	
Easily displaced with a water spray	Impossible to remove by rinsing or with the use of sprays	

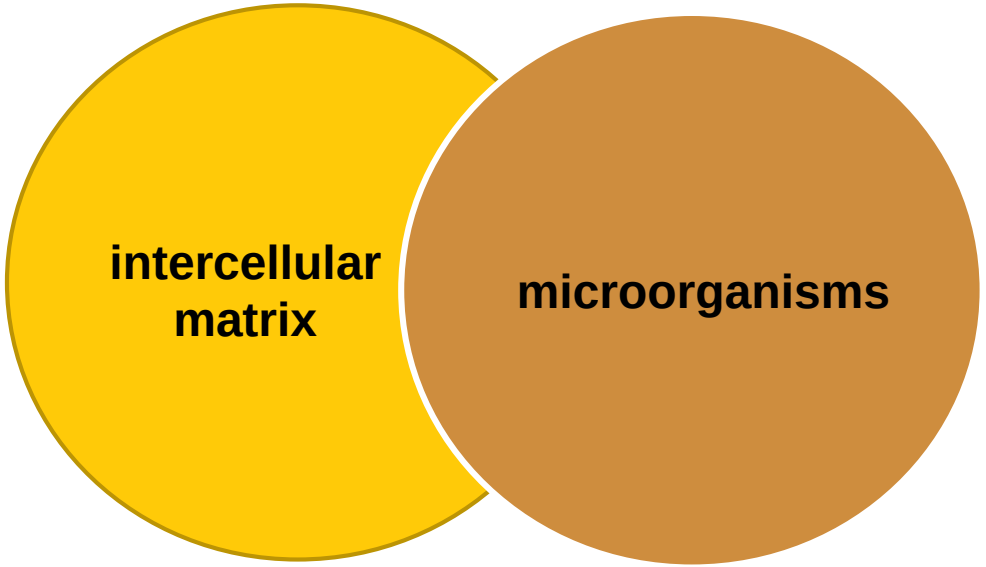
❖ ***Dental plaque as a Biofilm:*** structurally dental plaque is now considered to be a biofilm of complex and dynamic microbial community it contain area of high and low bacterial biomass interlaced with aqueous channels of different sizes which are the nutrient channels for bacterial colonization.

- The biofilm matrix functions as a barrier, So biofilm bacteria are often up to 1000 times more resistant to antimicrobial agents than their planktonic counterparts.



Composition of dental plaque

- Dental plaque is composed primarily of microorganisms. One gram of plaque (wet weight) contains approximately 10^11 bacteria.
- These microorganism found within an intercellular matrix.
- The number of bacteria in supragingival plaque on a single tooth surface can exceed 10^9 cells.
- In a periodontal pocket, counts can range from 103 bacteria in a healthy crevice to more than 10^8 bacteria in a deep pocket.



✓ **Non bacterial microorganisms that are found in plaque include yeasts, protozoa and viruses. The microorganism exist within an intercellular matrix that also contain a few host cells such as epithelial cells, macrophage and leukocytes**.

The intercellular matrix

Organic components

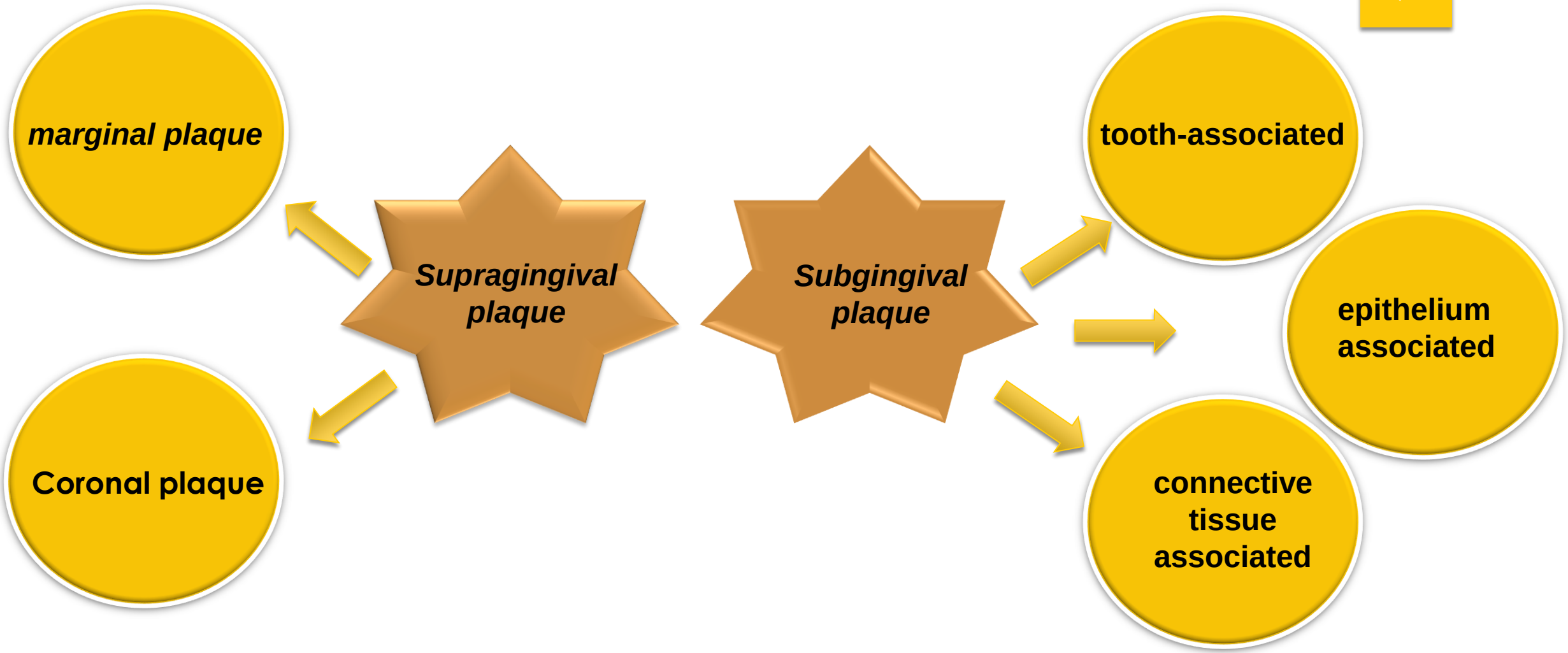
- Polysaccharides.
- Proteins.
- Glycoproteins.
- lipid material.
- DNA.

inorganic components

- predominantly calcium and phosphorus,
- trace amounts of other minerals such as sodium, potassium, and fluoride.

- ✓ **The source of inorganic constituents of supragingival plaque is primarily saliva.**
- ✓ **The inorganic components of subgingival plaque are derived from crevicular fluid (a serum transudate).**

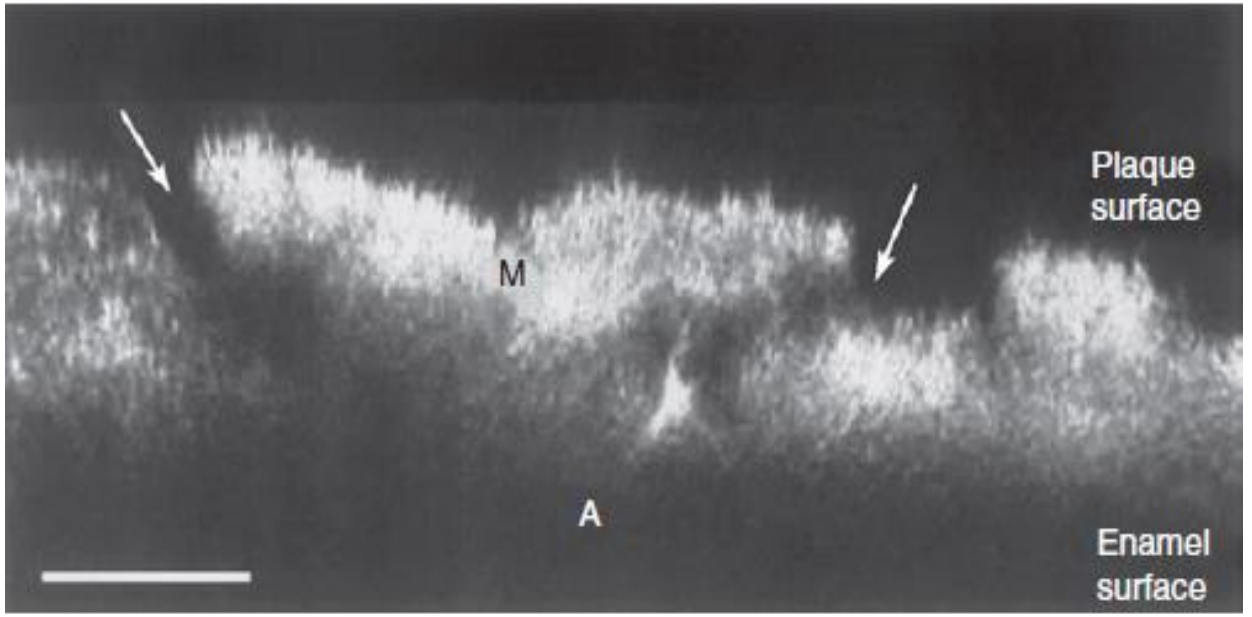
Classification of dental plaque



Classification of dental plaque

- ***Supragingival plaque*** is found at or above the gingival margin; when in direct contact with the gingival margin, it is referred to as ***marginal plaque***.

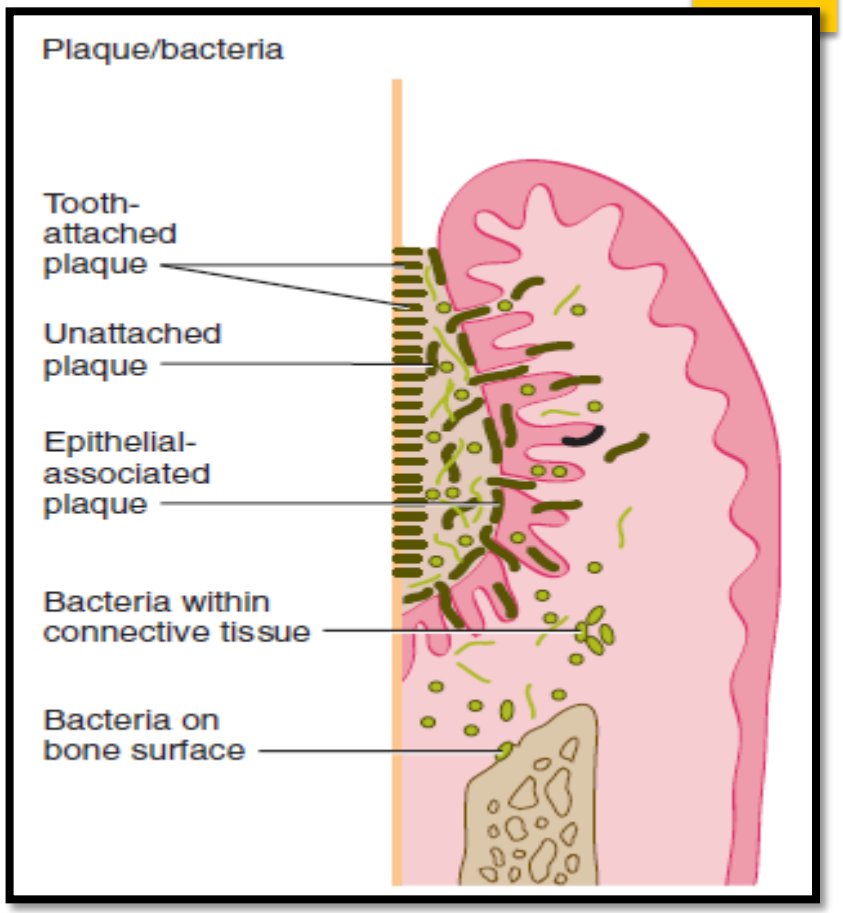
supragingival plaque



Vertical section through a 4-day human plaque sample

- ✓ ***Subgingival plaque*** is found below the gingival margin, between the tooth and the gingival pocket epithelium.

- ✓ Microbiologic studies indicate a differentiation of **tooth-associated regions** and the **soft tissue–associated regions of subgingival plaque** (epithelium associated Subgingival plaque and connective tissue associated.



Subgingival plaque: Diagram depicting the plaque–bacteria association between the tooth surface and the periodontal tissues

The site specificity of plaque is significantly associated with diseases of the periodontium

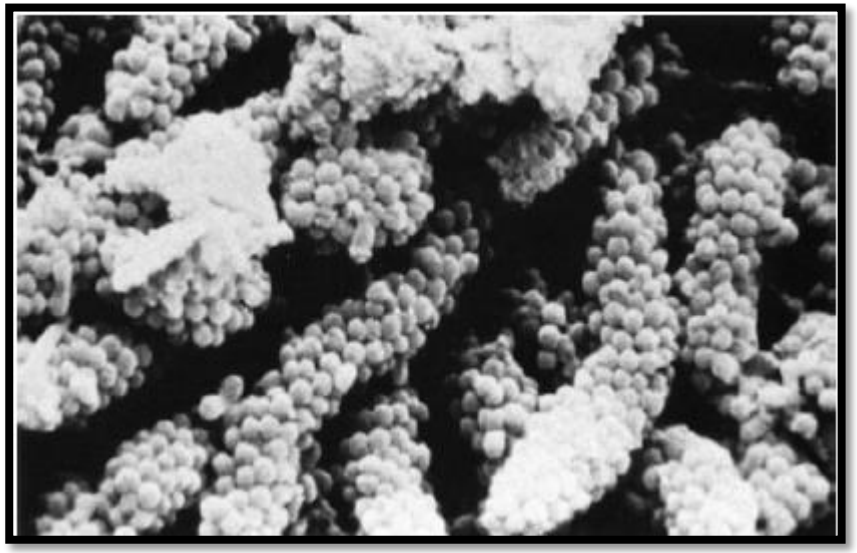
- ✓ **Marginal plaque**, for example, is of prime importance in initiation and development of gingivitis.
- ✓ **Supragingival plaque and tooth-associated subgingival plaque** are critical in calculus formation and root caries.
- ✓ **Tissue-associated subgingival plaque** is important in the tissue destruction that characterizes different forms of periodontitis.

Microscopic structure of dental plaque

- ❖ Supragingival plaque typically demonstrates a stratified organization of a multilayered accumulation of bacterial morphotypes.

- ❖ Grampositive cocci and short rods predominate at the tooth surface, whereas gram-negative rods and filaments ,as well as spirochetes, predominate in the outer surface of the mature plaque mass.

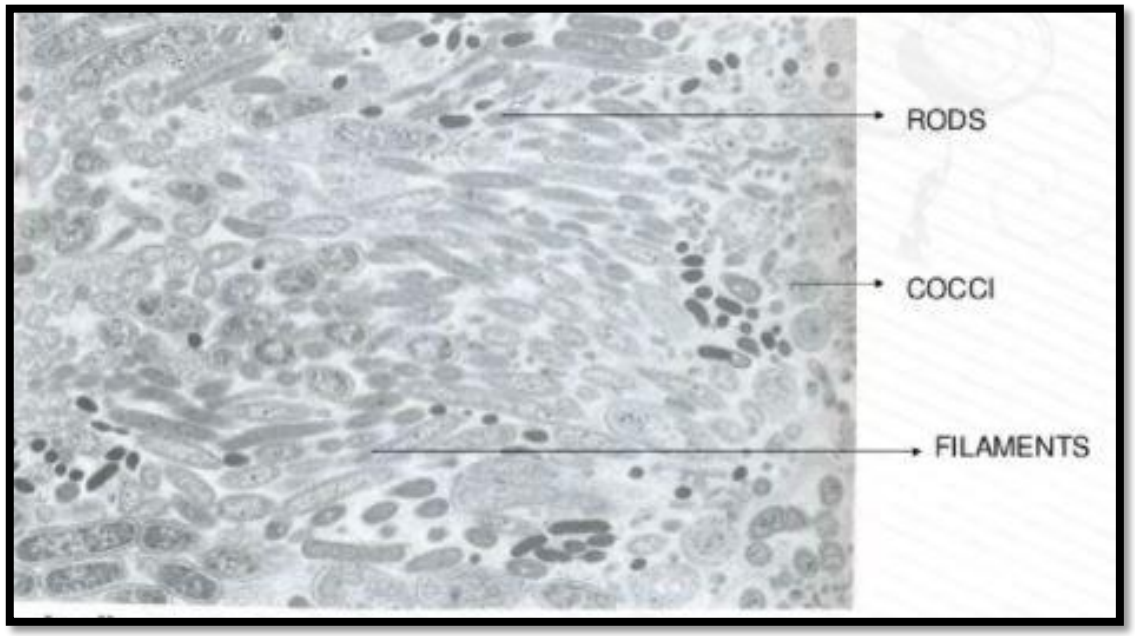
- ❑ Highly specific cell to cell interactions are also evident from the corncob structure aften abserved.



supragingival plaque near the gingival margin demonstrating a “corn cob” arrangement

- The subgingival microbiota differs in composition from the supragingival plaque, primarily because of the local availability of blood products and a low reduction-oxidation (redox) potential, which characterizes the anaerobic environment.

- The composition of the subgingival plaque depends on the pocket depth. The **apical part** is more dominated by spirochetes, cocci, and rods, whereas in the **coronal part** more filaments are observed.



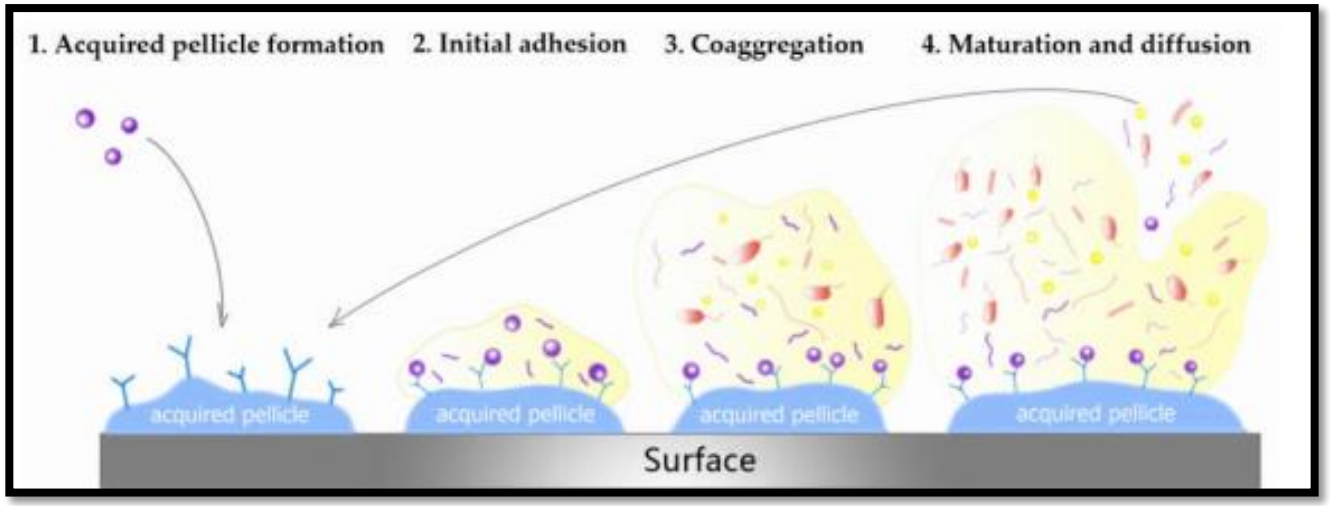
Development of dental plaque

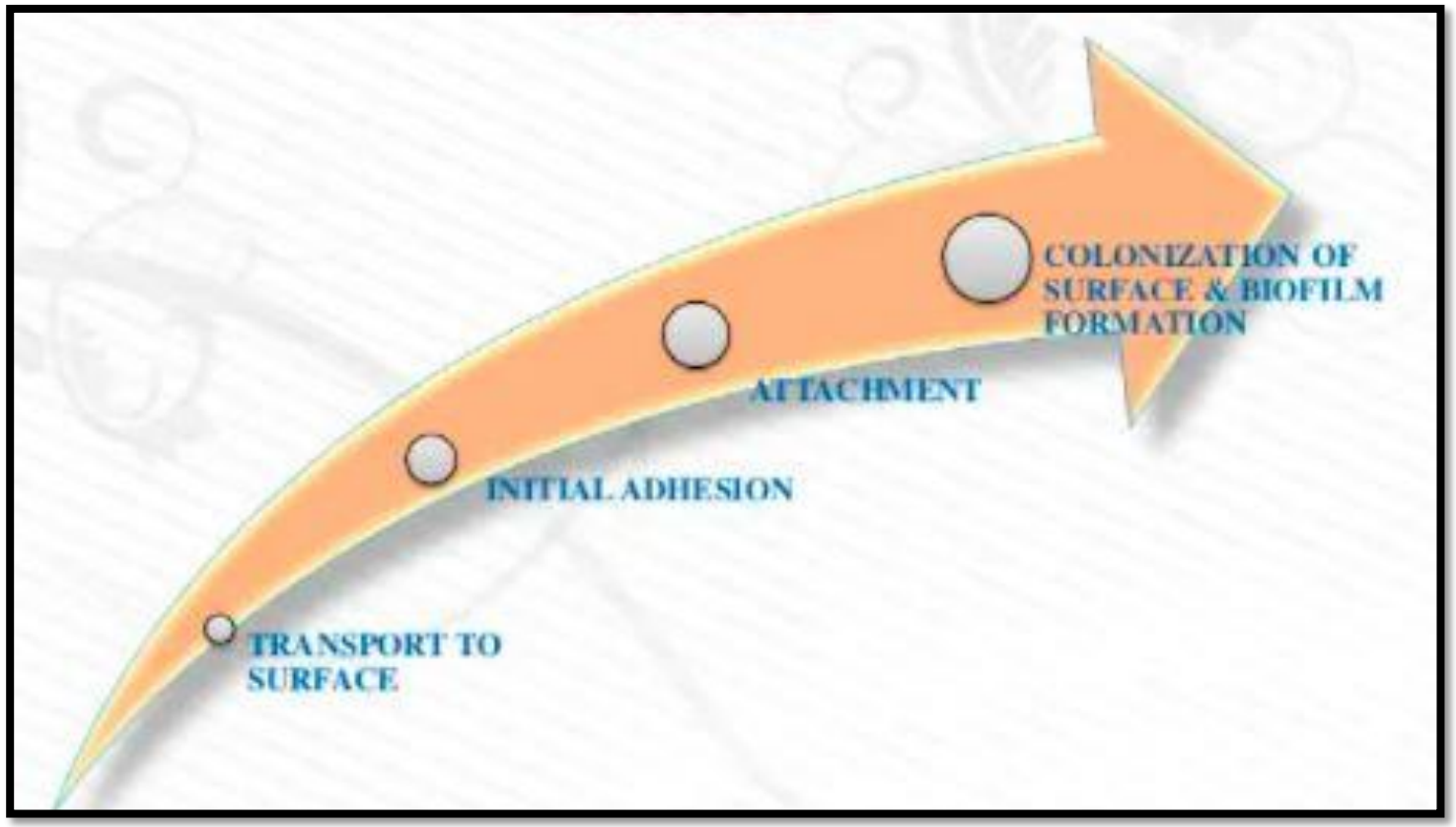
- The process of plaque formation can be divided into several phases:

The formation of the pellicle on the tooth surface

The initial adhesion/ attachment of bacteria

Finally, colonization/ plaque maturation




COLONIZATION OF SURFACE & BIOFILM FORMATION
ATTACHMENT
INITIAL ADHESION
TRANSPORT TO SURFACE

Formation of the Pellicle

- All surfaces in the oral cavity, including the hard and soft tissues, are coated with a layer of organic material known as the **acquired pellicle**.
- The salivary pellicle can be detected on clean enamel surfaces within 1 minute after their introduction into the mouths of volunteers.
- By 2 hours, the pellicle is essentially in equilibrium between adsorption and detachment, although further pellicle maturation can be observed for several hours.
- The pellicle on tooth surfaces consists of more than 180 peptides, proteins, and glycoproteins, including keratins, mucins, proline-rich proteins, phosphoproteins (e.g., statherin), histidine-rich proteins, and other molecules that can function as adhesion sites (receptors) for bacteria.
- Consequently, bacteria that adhere to tooth surfaces do not contact the enamel directly but interact with the acquired enamel pellicle.

Initial Adhesion/Attachment of Bacteria

- Colonizing bacteria can be detected within 3 minutes after the introduction of sterile enamel into the mouth.

- **The initial steps of transport and interaction with the surface are essentially nonspecific (i.e., they are the same for all bacteria)**.

- **The specific interactions** between microbial cell surface “adhesin” molecules and receptors in the salivary pellicle determine whether a bacterial cell will remain associated with the surface.

- Only a relatively small proportion of oral bacteria possess adhesins that interact with receptors in the host pellicle, and these organisms are generally the most abundant bacteria in biofilms on tooth enamel shortly after cleaning.

- Over the first 4 to 8 hours, the genus ***Streptococcus*** tends to dominate, usually accounting for >20% of bacteria present.

- Other bacteria that commonly present at this time include species that cannot survive without oxygen (obligate aerobes), such as ***Haemophilus* spp**. and ***Neisseria* spp.,**

- as well as organisms that can grow in the presence or absence of oxygen (facultative anaerobes), including ***Actinomyces* spp.** and ***Veillonella* spp.**

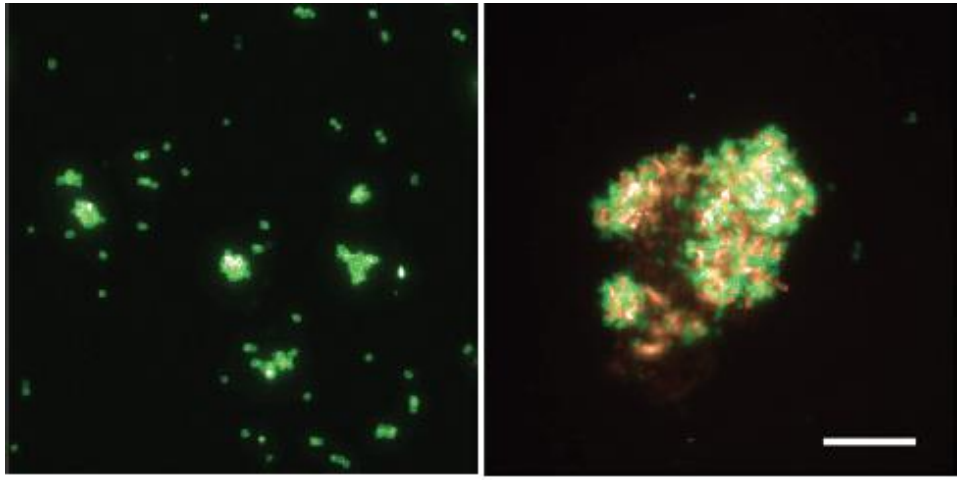
❖ These species are considered the "**primary colonizers**" of tooth surfaces. The primary colonizers provide new binding sites for adhesion by other oral bacteria. The metabolic activity of the primary colonizers modifies the local microenvironment in ways that can influence the ability of other bacteria to survive in the dental plaque biofilm. For example, by removing oxygen, the primary colonizers provide conditions of low oxygen tension that permit the survival and growth of obligate anaerobes.

Colonization and Plaque Maturation

- The primary colonizing bacteria adhered to the tooth surface provide new receptors for attachment by other bacteria as part of a process known as ***coadhesion***. coadhesion leads to the development of microcolonies and eventually to a mature biofilm.

- Secondary colonizers microorganism include ***Prevotella intermedia, Capnocytophaga spp, Fusobacterium nucleatum,*** and ***prophromonas gingivalis.***

  - *Fusobacteria* coaggregate with all other human oral bacteria while *Veillonella spp*., *Capnocytophaga spp*. and *Prevotella spp*. bind to *streptococci* and/or *actinomyces.*Each newly accreted cell becomes itself a new surface and therefore may act as a coaggregation bridge to the next potentially accreting cell type



Coaggregation between *Streptococcus gordonii* and *Actinomyces oris* in vitro

Factors affecting supragingival plaque formation

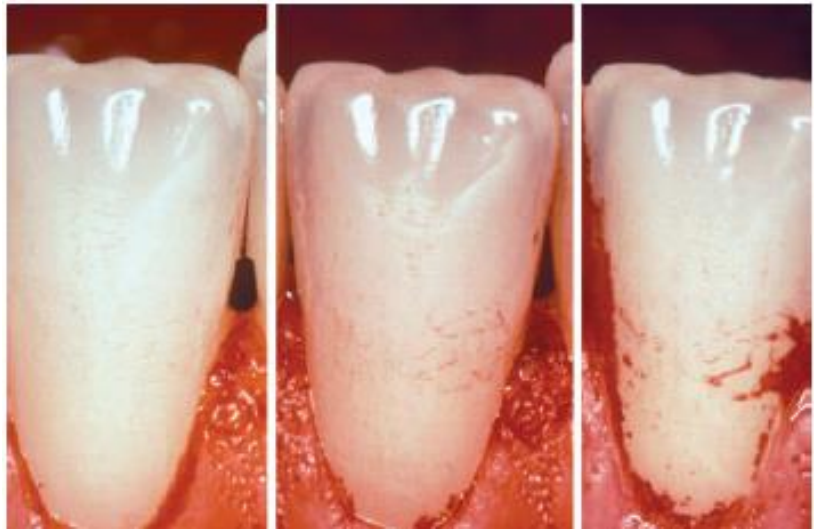
- During the first 24 hours starting from a clean tooth surface, plaque growth is negligible from a clinical viewpoint (<3% coverage of the vestibular tooth surface, which is an amount nearly undetectable clinically). This “lag time” is due to the fact that the microbial population must reach a certain size before it can be easily detected by clinician.

- During the following 3 days, coverage progresses rapidly, after 4 days, on average 30% of the total coronal tooth area will be covered with plaque.

Topography of supragingival plaque

- Early plaque formation on teeth follows a typical topographic pattern, with initial growth along the gingival margin and from the interdental space

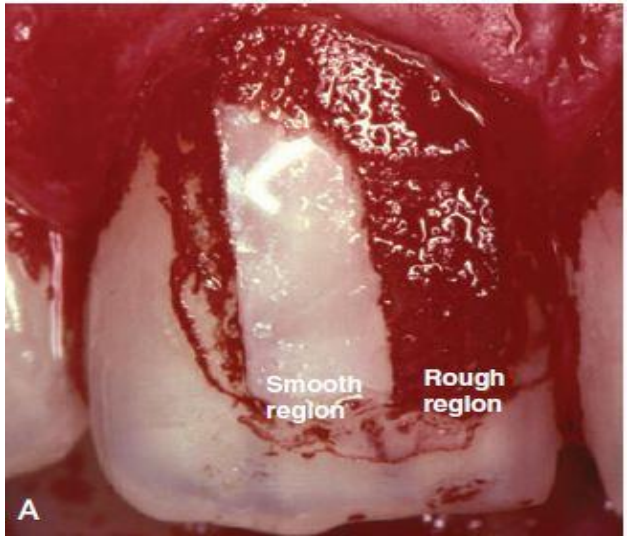
- Later, a further extension in the coronal direction can be observed. This pattern may fundamentally change when the tooth surface contains irregularities that offer a favorable growth path. Plaque formation can also start from grooves, cracks, or pits.



Typical topography of plaque growth

Surface Microroughness

- Rough intraoral surfaces (e.g., crown margins, implant abutments, denture bases) accumulate and retain more plaque and calculus in terms of thickness, area, and colony-forming units.



Surface irregularities and plaque growth

Individual Variables That Influence Plaque Formation

- The rate of plaque formation differs significantly among subjects, and these differences may overrule surface characteristics. A distinction is often made between “heavy” (fast) and “light” (slow) plaque formers.

Variation within the Dentition

- Early plaque formation occurs faster: in the lower jaw (when compared to the upper jaw).
- in molar areas; on the buccal tooth surfaces, when compared to palatal sites (especially in the upper jaw); and in the interdental regions when compared to the buccal or lingual surfaces.

Impact of Gingival Inflammation and Saliva

- Several studies clearly indicate that early in vivo plaque formation is more rapid on tooth surfaces facing inflamed gingival margins than on those adjacent to healthy gingivae. These studies suggest that the increase in crevicular fluid production enhances plaque formation. Probably, some substance(s) from this exudate (e.g., minerals, proteins, or carbohydrates) favor both the initial adhesion and/or the growth of the early colonizing bacteria.
- The supragingival plaque obtains its nutrients mainly from the saliva appears to be of greater significance than the antibacterial activity of saliva.

The Impact of Patient's Age

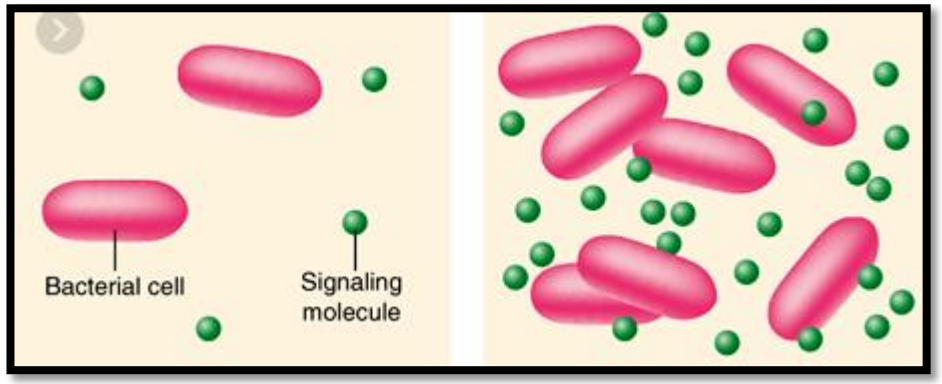
- Recent papers clearly indicate that a subject's age does not influence de novo plaque formation.

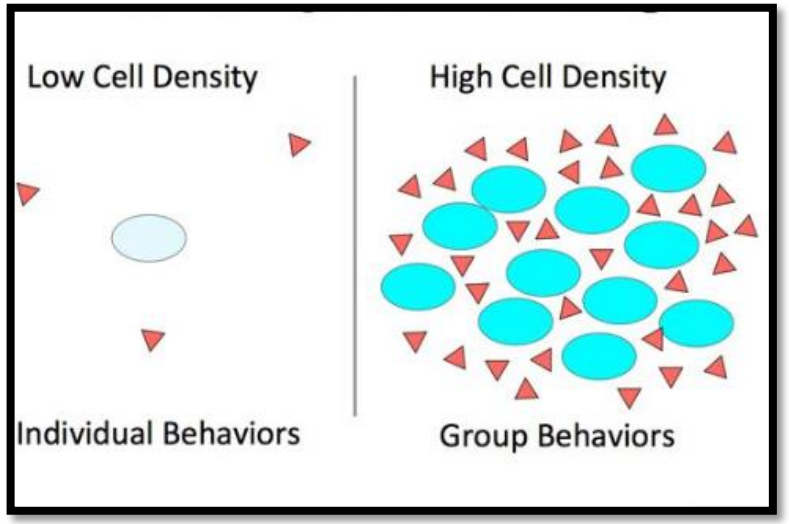
Spontaneous Tooth Cleaning

- Many clinicians still believe that plaque is removed spontaneously from the teeth such as during eating. However, based on the firm attachment between bacteria and surface, this seems unlikely. Even in the occlusal surfaces of the molars, plaque remains, even after chewing fibrous food (carrots, apples, or chips).

Communication Between Biofilm Bacteria

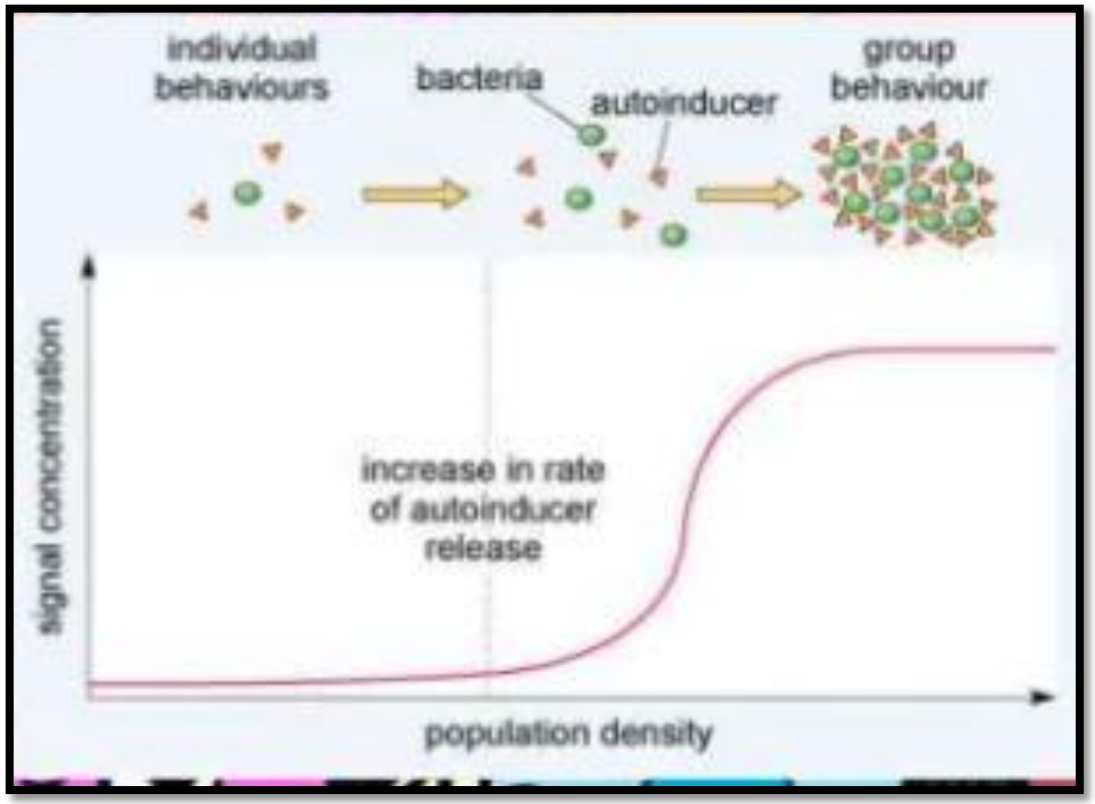
- In a biofilm, bacteria have the capacity to communicate with each other. one example of this is **quorum sensing**, **in which bacteria secrete a signaling molecule that accumulates in the local environment and triggers a response such as a change in the expression of specific genes once they reach a critical threshold concentration**.





- the threshold concentration is reached only at a high-cell density, and therefore bacteria sense that the population has reached a critical mass, or quorum.

- There is some evidence that intercellular communication can occur after cell-cell contact and in this case, may not involve secreted signaling molecules.




Thank you
for Listening!