

# Oral microbiology

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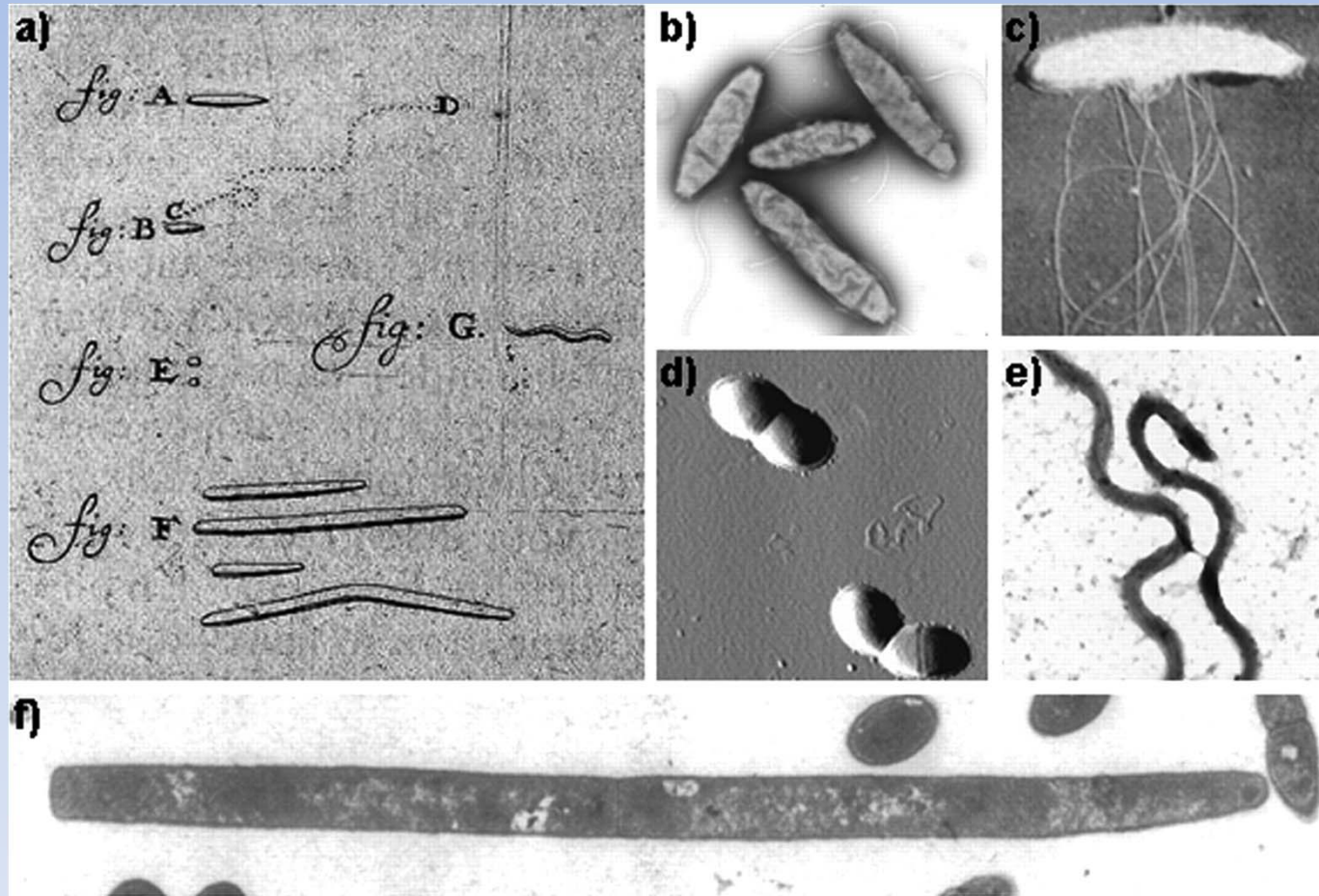
# Oral microbiology

- Oral cavity
- Dental plaque
- Dental caries
- Parodontitis
- Systemic infections
- Infections manifested in oral cavity
- Biofilms in GP office

# Oral health consequences

- Atherosclerosis of coronary vessels
- Stroke
- *Diabetes mellitus*
- Pre-term delivery
- Low birth weight
- Aesophagal carcinoma

# Oral microbiology started with Leeuwenhoek



*Animacules*

(a) Leeuwenhoek's drawings & charts; (b) *Campylobacter rectus*; (c) *Selenomonas sputigena* ; (d) oral cocci; (e) *Treponema denticola*; (f) *Leptotrichia buccalis*

# Description of dental plaque

- Anthony van Leeuwenhoek  
– 1632-1723



# **Microflora of the oral cavity**

# Oral microflora

- More than 700 genera
- Resident & transient
- Ecological system
- Biofilm formation
- Important for health
- Relation to etiology of dental caries, parodontitis, halitosis...

# Ecosystem of oral cavity

- Specific environment
- Mucosal surfaces
- Sulcar liquid
- Communicates with outer environment
- Influenced by ingested food



# Oral cavity as microbial biotop

- Lips
- Buccal mucosa & soft palate
- Tongue
- Supragingival teeth surfaces
- Sulci gingivales

# Particular surfaces in oral cavity I.

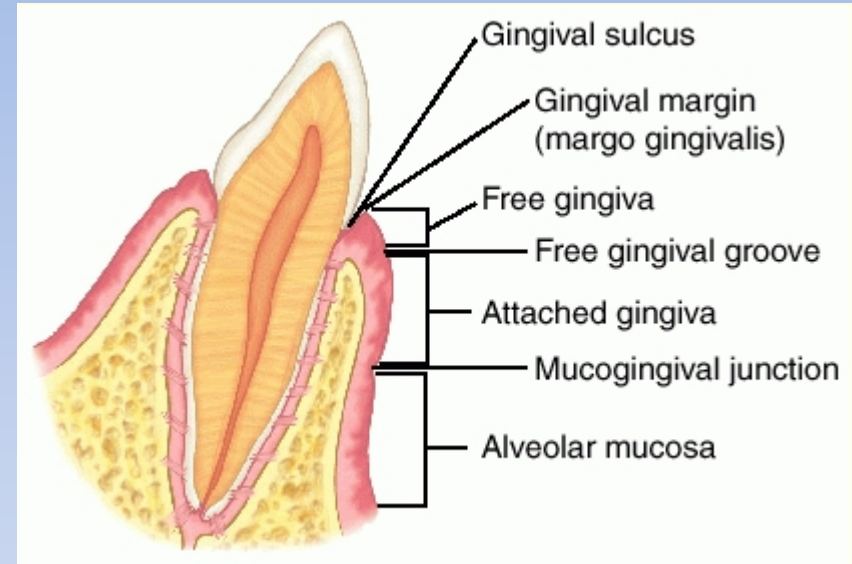
- **Lips**
  - Well aerated, dry environment
- **Buccal mucosa & soft palate**
  - Detachment
  - Rich in nutrients, well aerated
  - Biofilm layer weaker
- **Surface of the tongue**
  - Rich colonisation
  - Transient microorganisms

# Particular surfaces in oral cavity II.

- Papillar region - anaerobes
- **Teeth**
  - Ideal surface for bacteria, that form dental plaque
- **Mucous membrane of sulcus gingivalis**
  - Differs according to conditions of sulci
- **Artificial teeth and dental implantates**
  - Specific microflora

# Sulcus gingivalis

- Sulcar fluid
- Rich in nutrients
- Mix of aerobic and anaerobic species



# Streptococci in the oral cavity I.

- A-haemolytic streptococci
- ***S. mutans* group**
  - *S. mutans*
  - Less frequent *S. sobrinus*, *S. cricetus* and *S. rattus*
- ***S. salivarius* group**
  - *S. salivarius*, *S. vestibularis*
  - Mucous colonies
  - Can cause endocarditis

# Streptococci in the oral cavity II.

- ***S. mitis* group**

- *S. mitis*, *S. oralis*, *S. peroris*

- Can cause sepsis lenta

- *S. sanguinis* and *S. gordonii*

- *S. sanguinis*

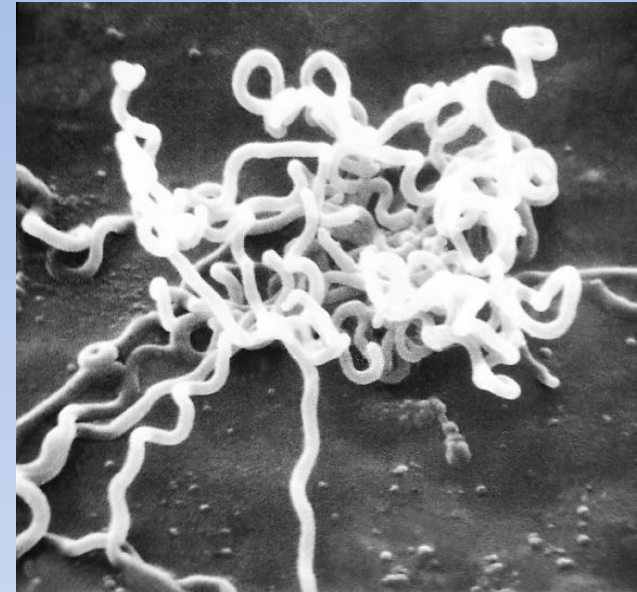
- Can cause IE

- ***S. anginosus* group**

- *S. anginosus* (*S. milleri*), *S. constellatus* – *S. c. constellatus* and *S. c. pharyngis*, and *S. intermedius*

# *Treponema denticola*

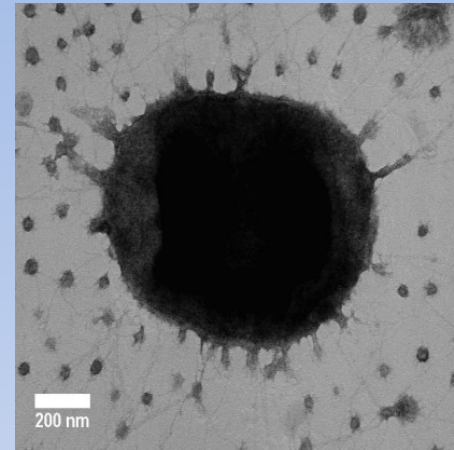
- Proteolytic
- Coaggregation with fusobacteria, porphyromonades
- Close relationship to *P. gingivalis*
- Motility
- Chemotaxis
- Adhesins, invasins
- Haemolysins
- Inflammatory starters



[wikipedia.org/wiki/Treponema](http://wikipedia.org/wiki/Treponema)

# *Porphyromonas gingivalis*

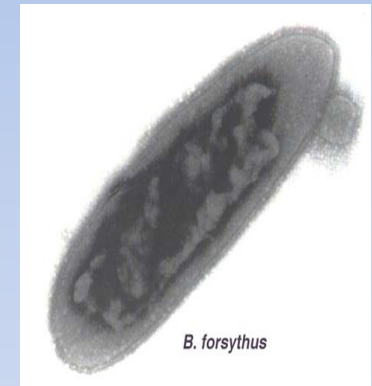
- Highly proteolytic
- Short & long fimbriae
- Quickly resides *sulcus gingivalis*
- Crossfeeding with *T. denticola*
- Releases outer membrane vesicles for the invasion of *Tannerella forsythia*
- Fimbriae – coculture with *S. gordonii*



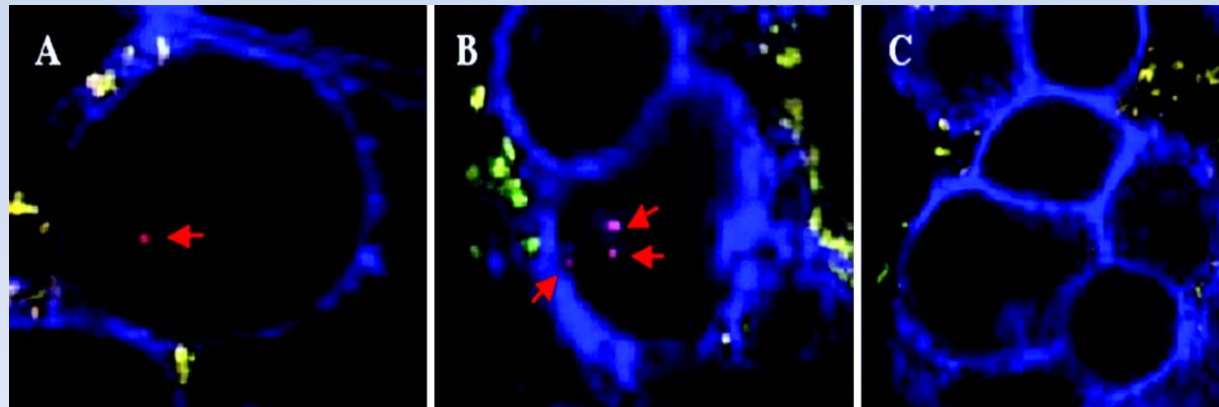


# *Tannerella forsythia*

- Interaction between *T. forsythia* and *P. gingivalis*
- Member of the red complex of periodontal pathogens



Invasion of *T. forsythia* into cells, Inagaki 2006, confocal laser microscopy

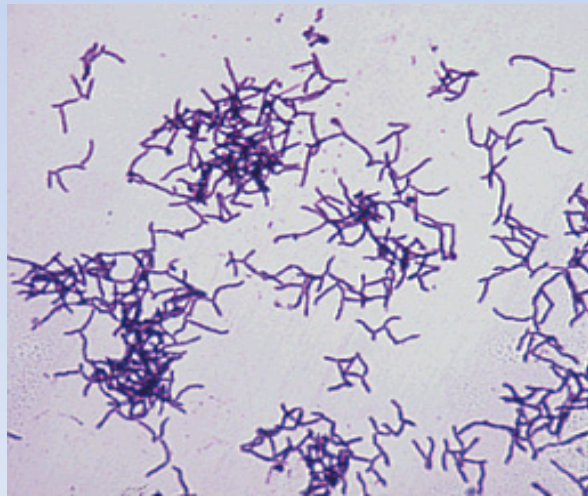


# Other G+ and G- bacteria

- *N. subflava*, *N. sicca*, *N. mucosa*
- Staphylococci, micrococci
- *Eikenella*
- *Veillonella*
- Other genera – *Propionibacter*, *Enterococcus* – less than 1%

# Mycoplasmas, actinomyces, lactobacilli

- *Actinomyces* sp.
- *Lactobacillus* sp.– less than 1%
- *Mycoplasma pneumoniae*, *M. hominis*, *M. salivarium*



# Interactions of microorganisms

- Products of metabolism
- *Fusobacterium nucleatum* protects *P. gingivalis*
- Bacteriocins – natural antibiotics

# Protection against immunity system

- Susceptibility depends on microorganism
- Some of them more resistant to phagocytosis
- Metastatic infections

# Parasites and fungi in oral cavity

- *Entamoeba gingivalis*, *Trichomonas tenax*
- *Candida* sp.
  - Immunocompromised patients
  - ECC relation???

# Dental plaque

# Plaque

- Dental plaque - adherent microbial layer
- Can not be washed
- Composition variable
- According to the location
  - Supragingival
  - Subgingival
- Sometimes also classified as coronary, fissural, supragingival and subgingival

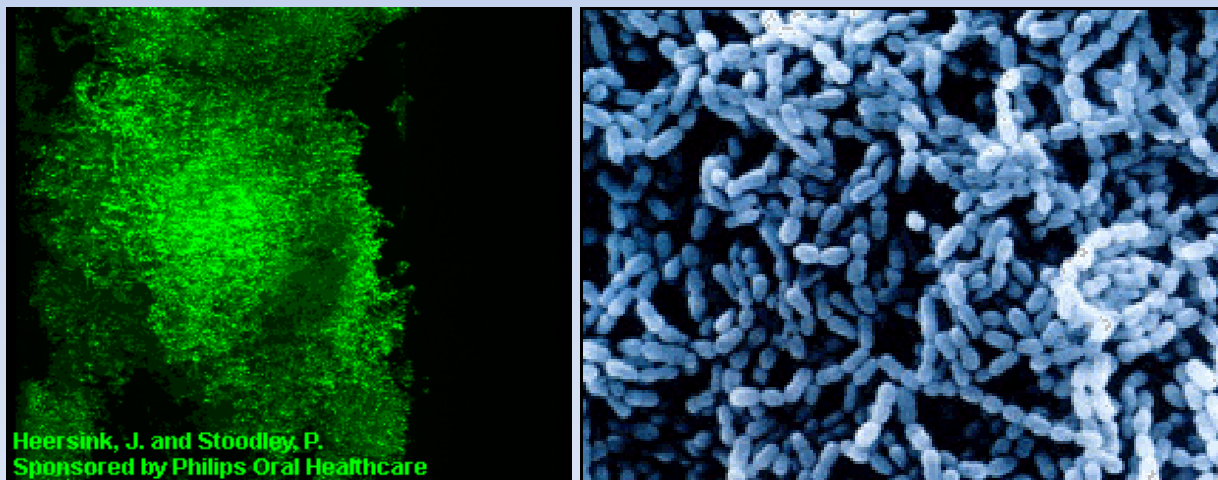


# Definition of biofilm

- Sessile microbial community
- Cells irreversibly attached to a substratum or interface or to each other
- Highly resistant to outer influences

# Dental plaque

- It is composed of numerous bacteria
- In disease - shift
- Open architecture similar to other biofilms



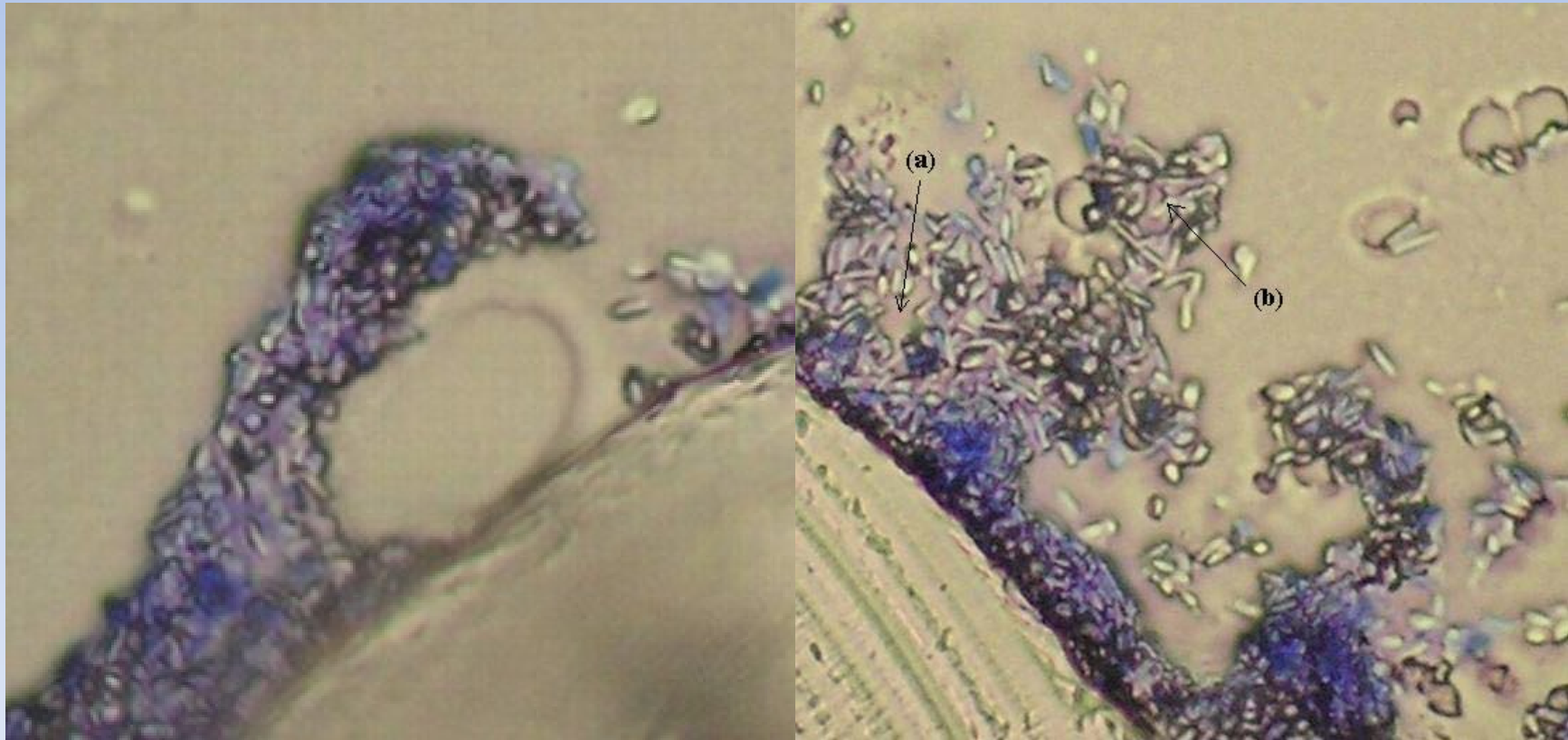
# Biofilm architecture



# Oral microflora

(a) channel

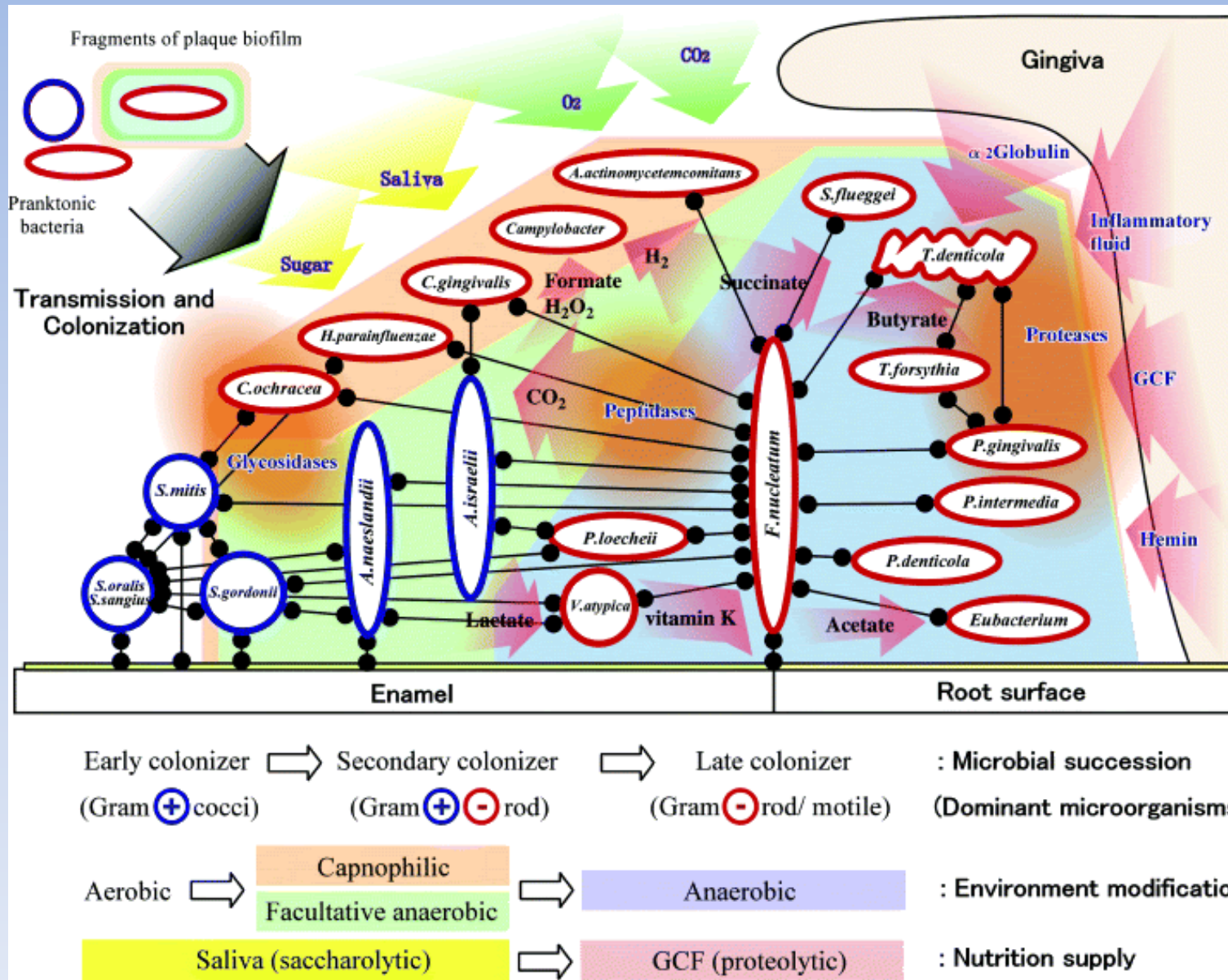
(b) fungoid structure



# Mutual relations between biofilm bacteria

- Bacteria in plaque communicate mutually
  - Physically
  - Biochemically
  - *Quorum sensing*

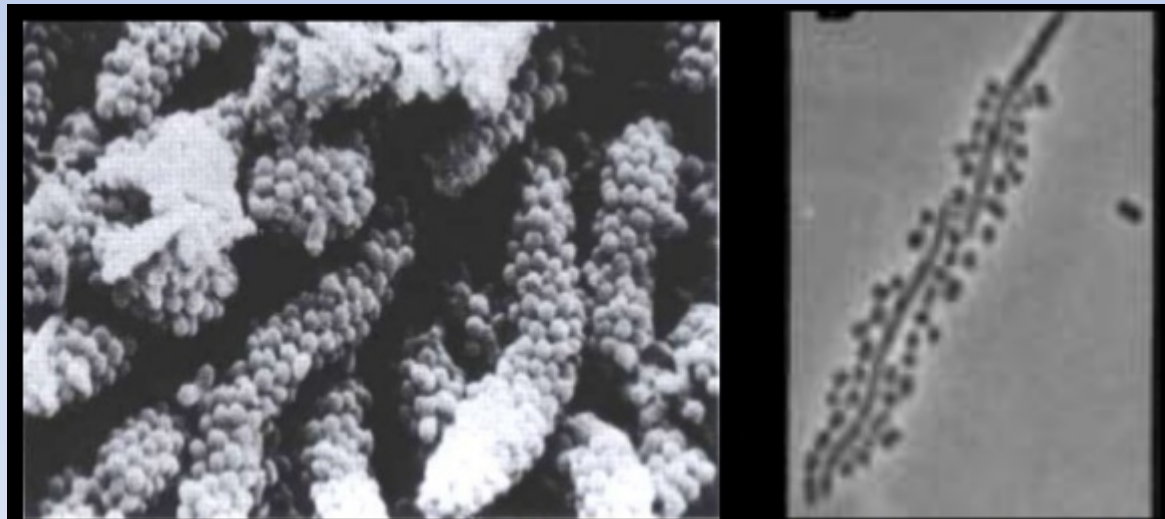
# Relations of bacteria in the plaque



<http://dentalplaque.wikispaces.com/Formation>

# Coaggregation in plaque

- E.g. anaerobic *Fusobacterium nucleatum*
  - Early colonizers of the tooth surface
  - Anaerobic late colonizers



# Dental plaque development mechanisms I.

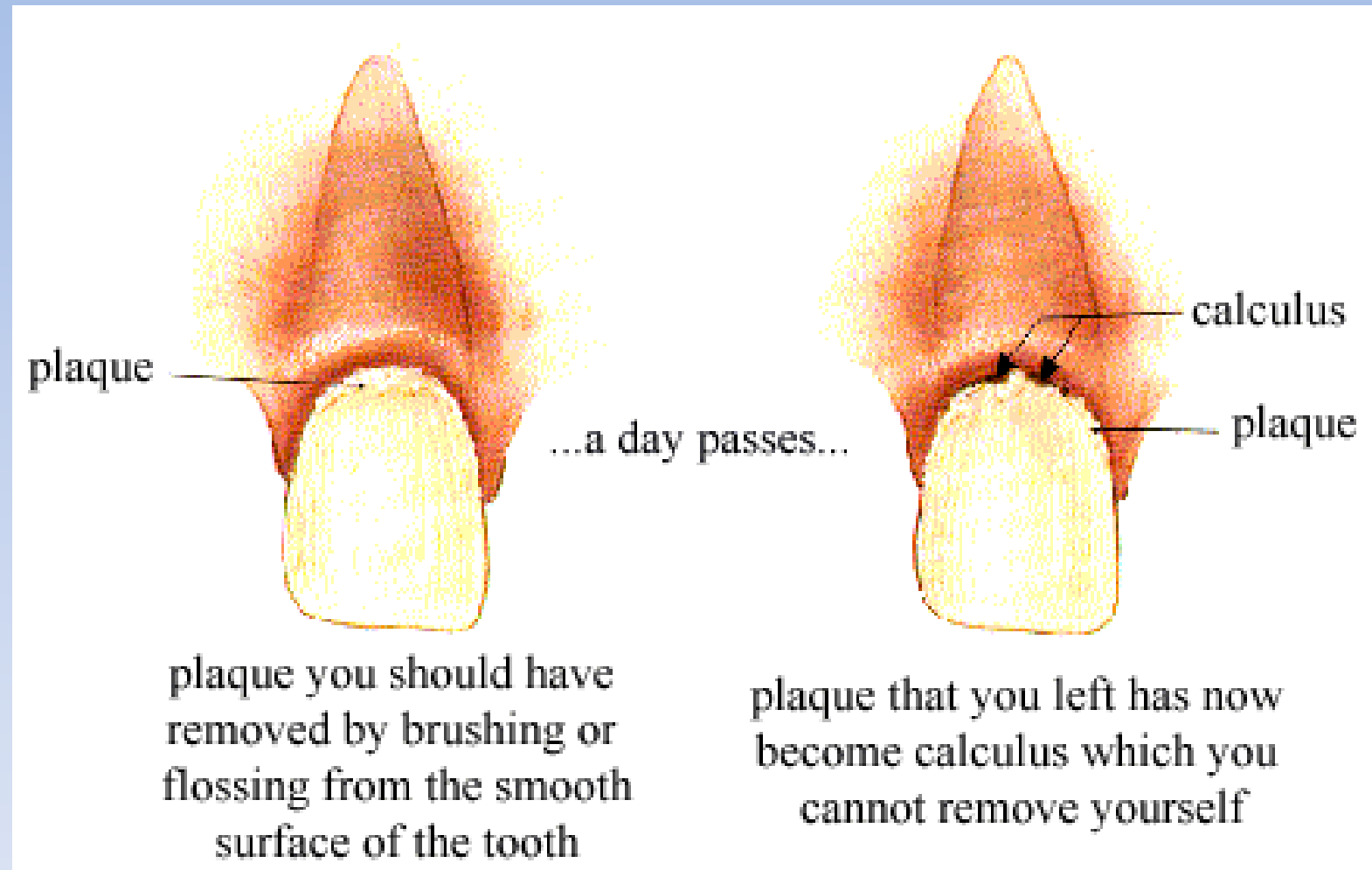
- Pellicula
- Surface of enamel, source of some ions (calcium, phosphorus)
- Glycoproteins - receptors for adhesion of G+ cocci and rods
- Exopolysaccharid production
- Bacterial metabolism in plaque



# Dental plaque development mechanisms II.

- In bottom layers – mineralisation
- Finally ca. 80% minerals
- Bacterial metabolism
- pH decreases to  $< 5.5$  – enamel demineralisation
- Subgingival calculus - mostly G–microorganisms
- Calculus is porous

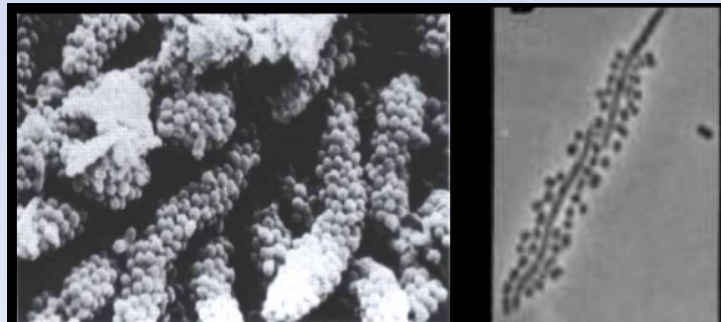
# Dental tartar



<http://www.intelligentdental.com/2011/12/03/what-are-the-causes-of-tartar-on-human-teeth/>

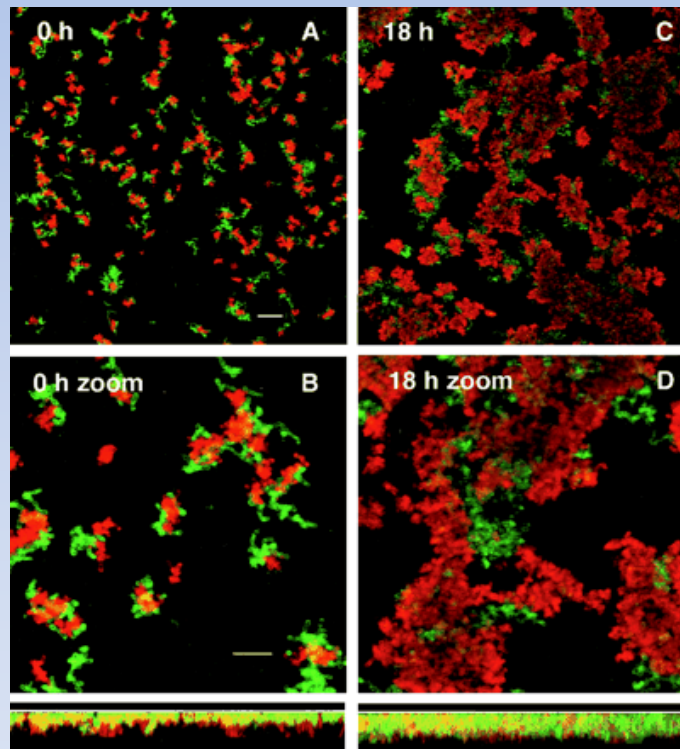
# Development of dental plaque

- Less than 24 hours: Streptococci prevalent
- Days: G+ rods and filamentous microorganisms
- Week: Columns/microcolonies of coccoid microbes – rods and filamentous microbes attached
- Three weeks: filamentous microbes prevalent, „corn-cob“ formation



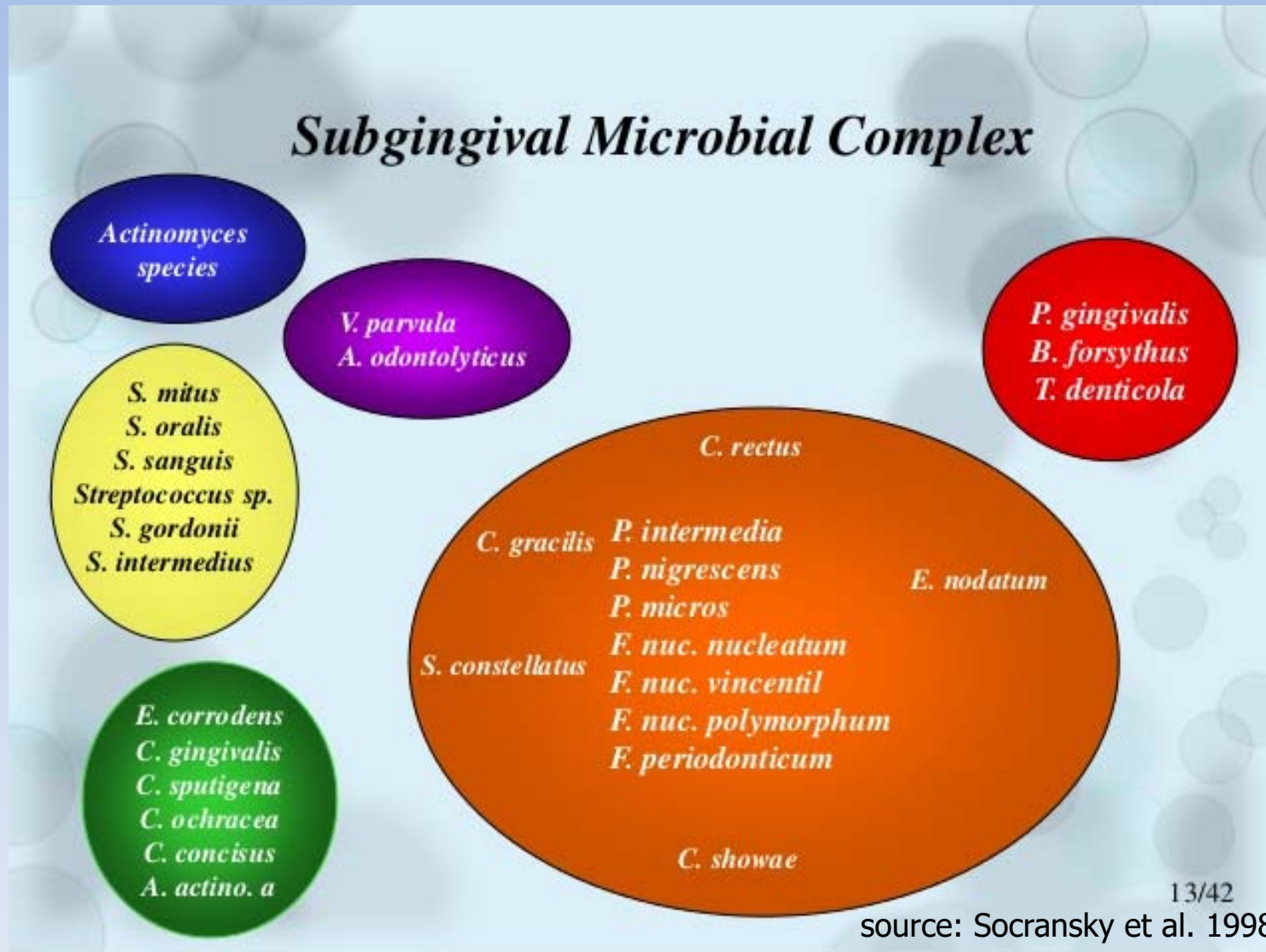
# Oral microflora

- Microcolonies development



Confocal laser microscopy – two-species biofilm, Kolenbrander et al., 2002

# Bacterial complexes in the oral cavity

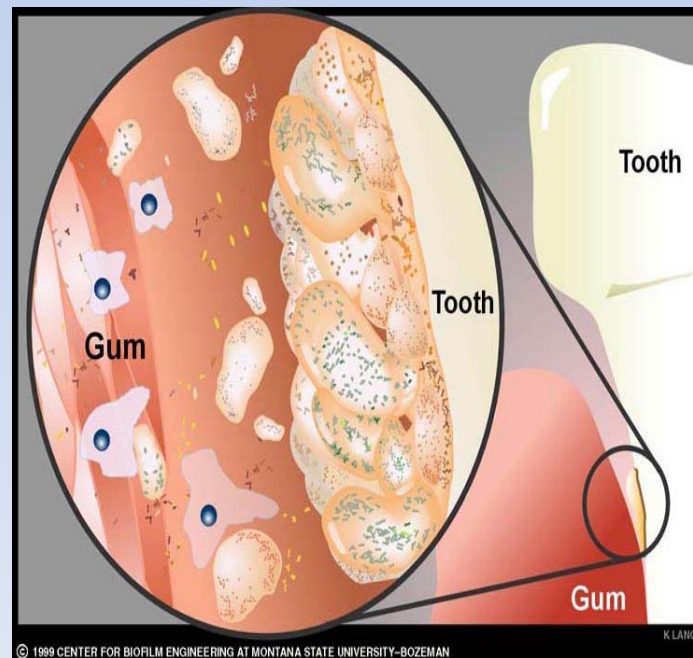


# Distribution of microorganisms

- *Actinomyces* sp.
- Supragingival plaque
- Subgingival plaque
- Supragingival plaque - reservoir for infections of subgingival space

# Subgingival plaque

- Adherent plaque – adherent to the dental root
- Non-adherent plaque – between adherent plaque and gingival surface

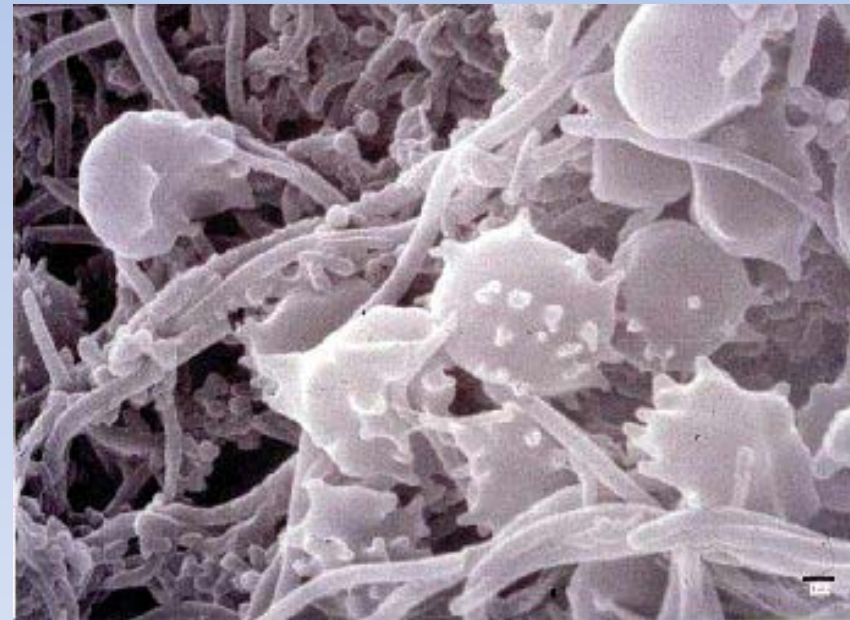
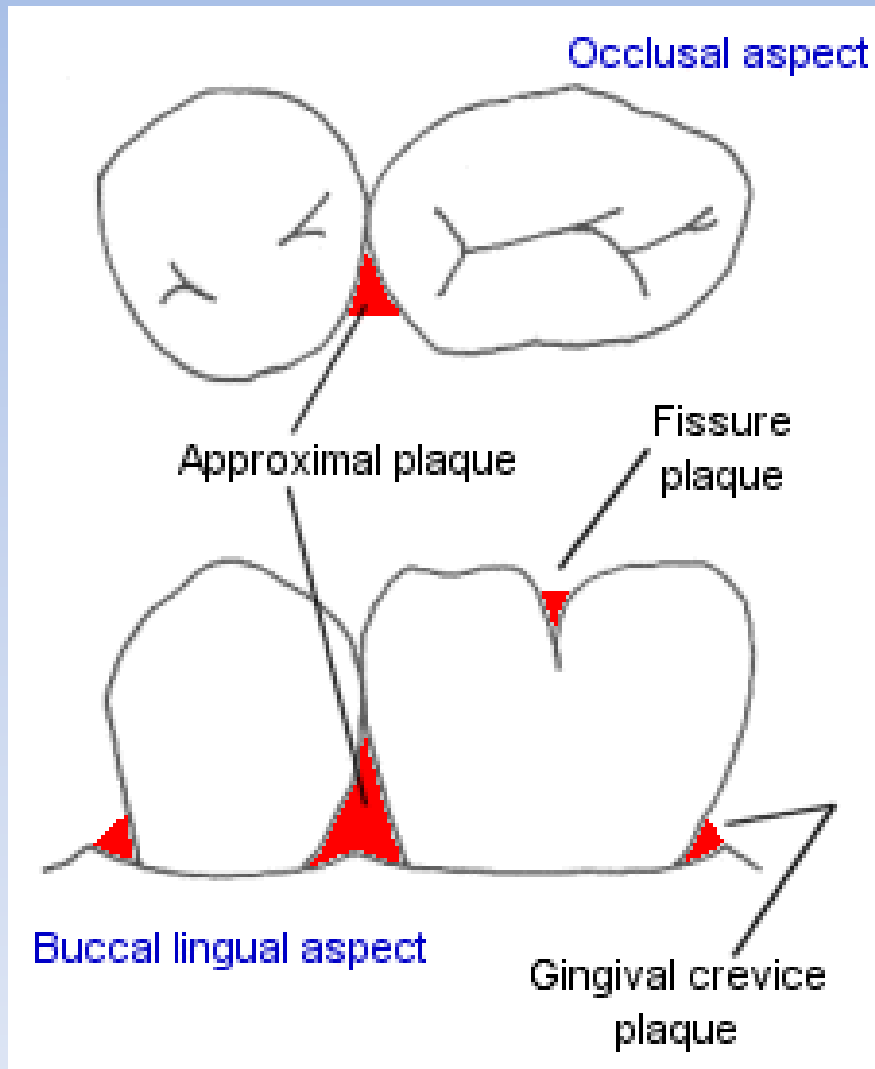


# Subgingival plaque

<b>Adherent part</b>	<b>Non-adherent part</b>
<b>Rather Gram-positive</b>	<b>Rather Gram-negative</b>
<b>Rather non-motile</b>	<b>Rather motile</b>
<b>Rather facultative anaerobes</b>	<b>Rather strict anaerobes</b>



# Supragingival plaque



# Supragingival plaque

- *Actinomyces* sp.
- Supragingival plaque
- Periodontal pathogens can be occasionally found in supragingival plaque



# Dental plaque on dental plates

- Different and fluctuating composition
- Streptococci
- *Candida* sp.
- Anaerobes G+ rods, but also G- cocci -  
*Veillonella* sp.
- Commonly also staphylococci, mostly  
STAU



# **Microbiology of dental caries**

# Dental caries

- Bounded destruction of tooth tissue
- Multifactorial illness
- Affection

# Endogenous factors

- Tooth profile
- Structure of enamel
- Saliva

# Nutrition

- Direct relation
- Saccharose
- Consumption
- Also glucose, galactose, lactose, soluble amyls



# Microbial factors

- Specific plaque hypothesis
- Unspecific plaque hypothesis
- Most of microbes present have biochemically cariogenic potential
  - But *S. mutans*, lactobacilli and actinomyces have stronger potential

## ***S. mutans* group**

- Most commonly *S. mutans* c, e & f and *S. sobrinus* d & g
- Often isolated from enamel just before caries formation
- Correlation of their numbers and progression of caries lesion
- Glucans formation
- Survive and multiply in low pH
- Create low pH environment very rapidly - demineralization

# Lactobacilli

- High numbers in caries lesions
- Correlation of caries activity and their numbers in plaque and saliva
- Multiply in low pH
- Form lactic acid

**BUT**

- In the initial caries lesions commonly not present

# Actinomycetes

- Actinomycetes relation to dental root caries

## *Veillonella*

- Higher numbers in most of supragingival plaques

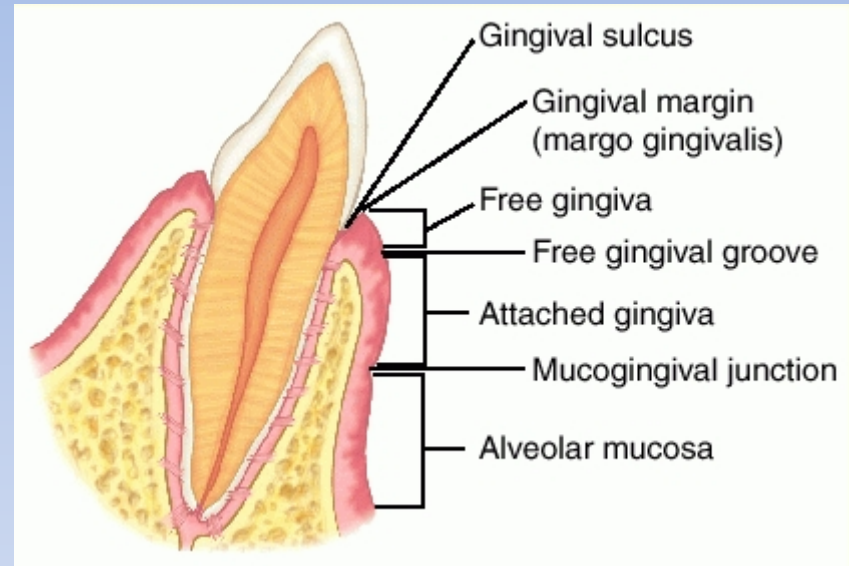
# Dental root caries

- Actinomycetes – *A. naeslundii*, *A. odontolyticus*, *A. gerensceriae*
- Low numbers of *S. mutans* group & lactobacilli
- In the microflora higher ratio of G- species

# Microbiology of parodontitis

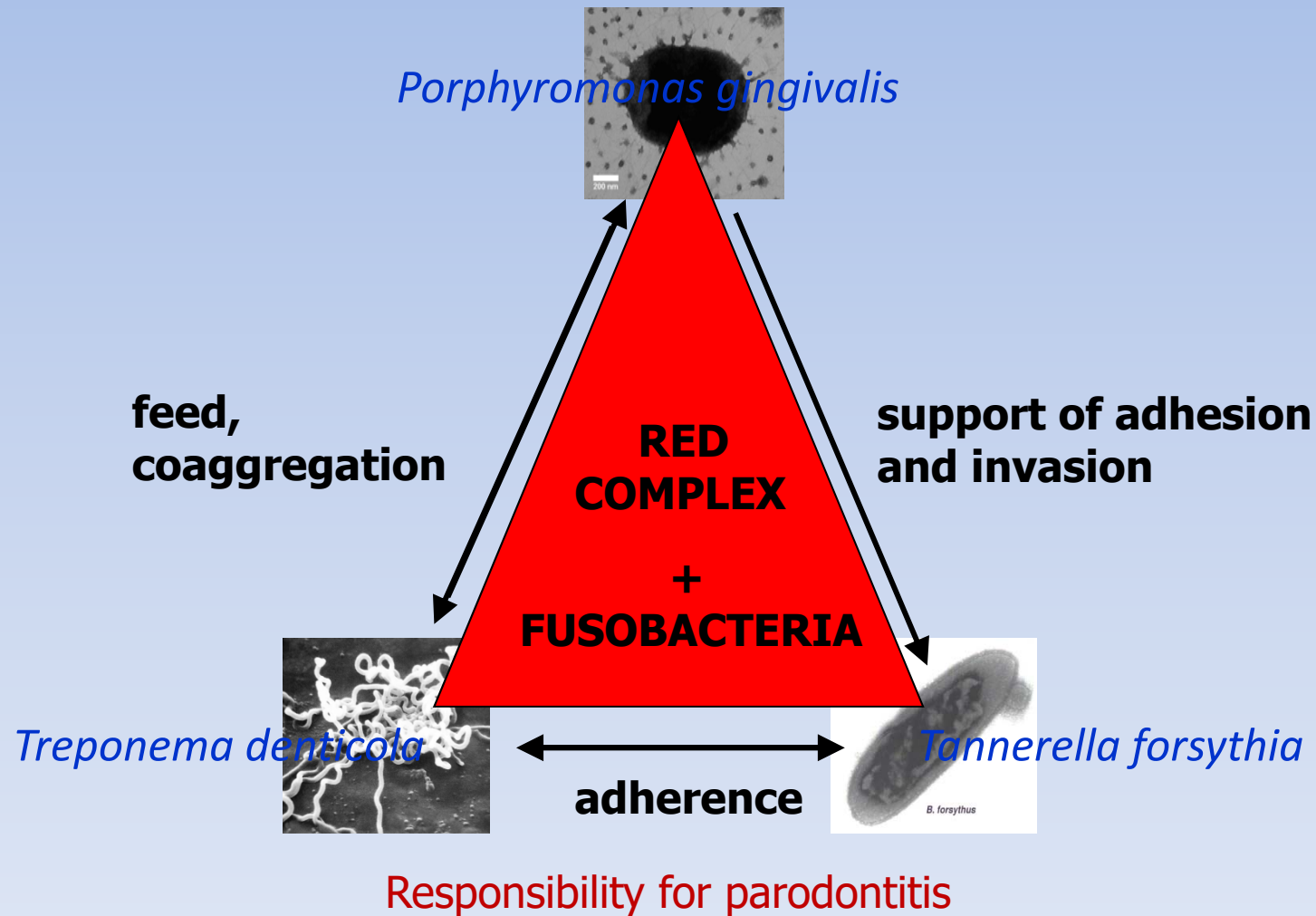
# Sulcus gingivalis I.

- Anaerobic environment
- Rich in nutrients



- Mix of aerobic and anaerobic species
- **RED COMPLEX** bacteria...

# Red complex bacteria





# Sulcus gingivalis II.

## ANAEROBES

*Aggregatibacter (Actinobacillus) actinomycetemcomitans*

*Actinomyces* – *A. gerencseriae*, *A. georgiae*

*Fusobacterium* – *F. nucleatum*, *F. alocis*, *F. sulci*

*Prevotella nigrescens*

*Porphyromonas gingivalis*, *P. endodontalis*

*Treponema denticola*, *T. vincentii*, *pectinovarum*, *socranskii*

*Tannerella forsythia*

*Wolinella succinogenes*

*Selenomonas sputigena*

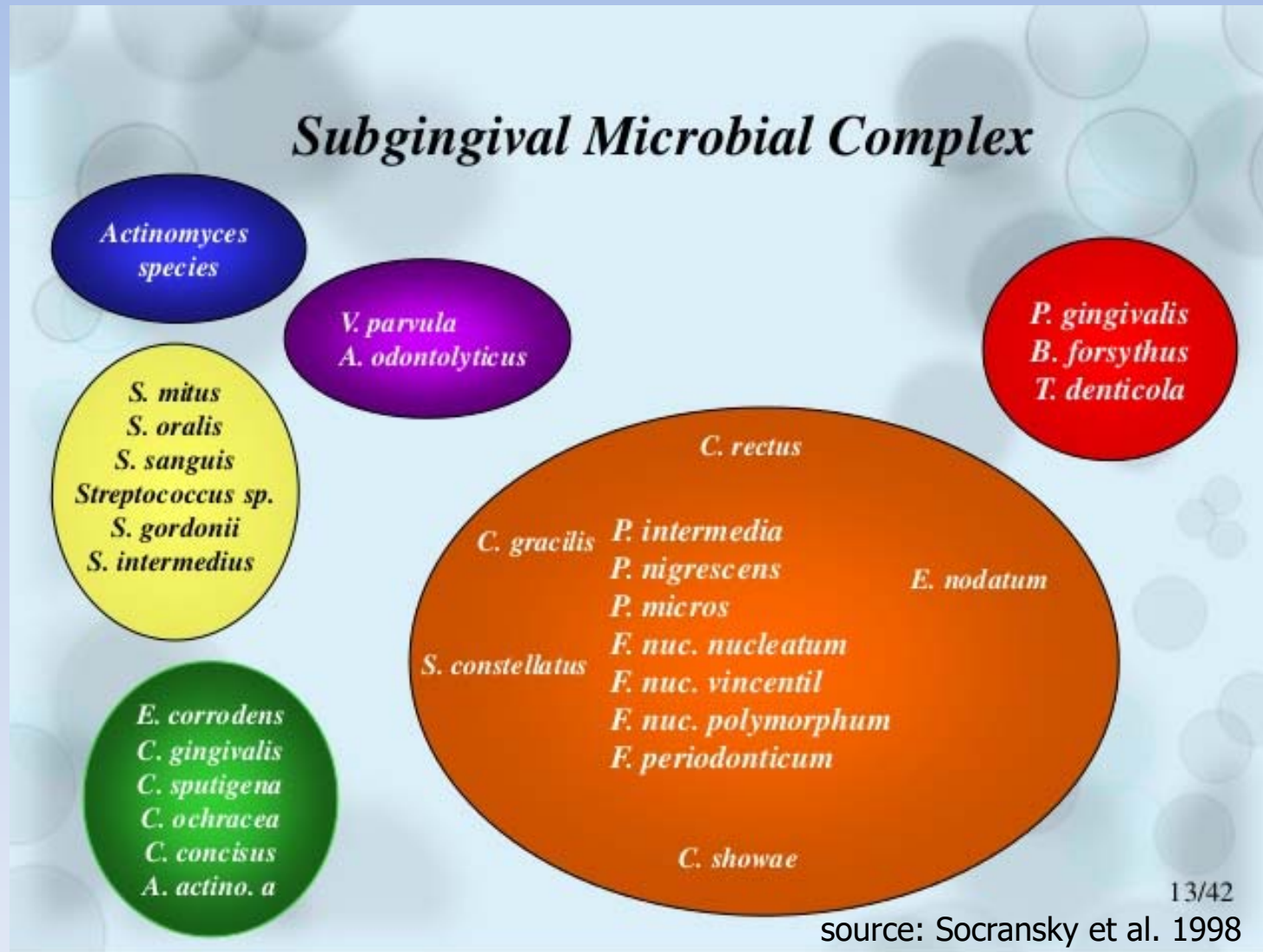
## AEROBES

*Streptococcus anginosus*, *Streptococcus constellatus* subsp.

*constellatus*, *Streptococcus constellatus* subsp. *pharyngis*,

*Streptococcus intermedius*

# Relationship of bacterial communities in parodontitis



# Subgingival microbial complexes I.

- **The red complex**
  - *Porphyromonas gingivalis*
  - *Tannerella forsythia*
  - *Treponema denticola*
- Categorized together based on their association with severe forms of periodontal disease
- Exhibit very strong relationship with pocket depth

# Subgingival microbial complexes II.

- **The orange complex**

- *Fusobacterium nucleatum*

- *Eubacterium nodatum*

- *Prevotella intermedia*

- *Campylobacter showae*

- *Prevotella nigrescens*

- *Campylobacter gracilis*

- *Peptostreptococcus micros*

- *Campylobacter rectus*

- *Streptococcus constellatus*

- *P. intermedia* is always detected in the presence of *F. nucleatum* in subgingival plaque samples from deep pockets
- All species in the orange complex showed significant association with increasing pocket depth

# Subgingival microbial complexes III.

- **The yellow complex**
  - *Streptococcus sanguis*
  - *Streptococcus oralis*
  - *Streptococcus mitis*
  - *Streptococcus gordonii*
  - *Streptococcus intermedius*
- Bacteria not directly associated

# Subgingival microbial complexes IV.

- **The purple and green complexes**
- Present in the periodontal pocket but not significantly associated with signs of periodontal disease progression
- Seems to prepare the way for the other bacterial complexes
  
- **The blue complex**
- Not associated with progression of periodontal disease

# **Systemic infections related to the oral microflora**

# Systemic infections

- Systemic illnesses
  - Metastatic infections
    - Bacteria
  - Metastatic injury
    - Toxins
  - Metastatic inflammation
    - Antigens



# Metastatic infection

- Via transient bacteremia
  - Subacute infective endocarditis
  - Acute bacterial myocarditis
  - Brain abscess
  - Cavernous sinus thrombosis
  - Sinusitis
  - Lung abscess/infection
  - Ludwig's angina
  - Orbital cellulitis
  - Skin ulcer
  - Osteomyelitis
  - Prosthetic joint infection

# Metastatic injury

- Circulation of oral microbial toxins
  - Cerebral infarction
  - Acute myocardial infarction
  - Abnormal pregnancy outcome
  - Persistent pyrexia
  - Idiopathic trigeminal neuralgia
  - Toxic shock syndrome
  - Systemic granulocytic cell defects
  - Chronic meningitis

# Metastatic inflammation

- Immunological injury from oral organisms
  - Behçet's syndrome
  - Chronic urticaria
  - Uveitis
  - Inflammatory bowel disease
  - Crohn's disease
  
- Weak data

# Bacteraemia

- *Propionibacterium acnes*
- *Peptostreptococcus prevotii*
- *Fusobacterium nucleatum*
- *Prevotella intermedia*
- *Saccharomyces cerevisiae*
- *Actinomyces israelii*
- *Streptococcus intermedius*
- *Streptococcus sanguis*

# Other consequences

- *P. gingivalis* - linked to rheumatoid arthritis
- *T. forsythia* - identified in atherosclerotic lesions

# Subacute infectious endocarditis

# Subacute infectious endocarditis

- Endocarditis
- Commonly - *S. sanguis* and *S. gordonii*, *S. oralis*, *S. peroris*
- Rarely - *S. salivarius*, *S. vestibularis*
- Difficult and long-term treatment

# Risk of IE I.

- **Low**
  - Defect of heart atrium septum
  - Implantation of pacemaker
  - After bypass surgery
- **Medium**
  - Congenital heart defects
  - Provisional surgery of heart defects
  - Rheumatoid valve defects
  - Prolaps MI valve
  - Hypertrophic obstruction cardiomyopathy
  - After surgical correction of cardiovascular defect



# Risk of IE II.

- ***High***
  - Heart valve replacement
  - After IE
  - After surgical correction of cardiovascular deffect

# Therapy recommendation

- ATB prophylaxis
- Medium risk
  - Adults: AMC 2g in 1 dose 1 hr prior to intervention
  - Children: AMC 50mg/kg, max. 3g in 1 dose 1 hr prior to intervention
- High risk
  - Adults: AMC 2g in 1 dose 1 hr prior to intervention, followed by 750 mg/6 hrs (7 doses)
  - Children: AMC 50mg/kg, max. 3g in 1 dose 1 hr prior to intervention, followed by 15 mg/kg/6 hrs (7 doses)

# Therapy recommendation

- In PNC allergy alternatively CLI (600mg, children 15 mg/kg 1 hr prior to intervention)
- In high risk continue with 300 mg/6hrs (7 doses), children 7,5 mg/kg/6hrs (7 doses)

# Biofilms in GP office

# Two forms of microbial growth

- Growth in the planktonic form
  - In the fluid environment the isolated microbial cells freely float
- Growth in the biofilm form
  - Natural tendency to stick to each other and to solid surfaces
  - Form a community

# Which form is more frequent?

- Planctonic form
  - Common in the laboratory (e.g. in broth)
- Biofilm form
  - Primary in the natural environment because it is more advantageous for the microbes

# Definition of biofilm

- Sessile microbial community
- Exhibit an altered phenotype
- Highly resistant to outer influences

# Biofilm in GP/dental office I.

- Waterlines = ideal environment for microbial colonization → biofilm
- Source of microbes
- Consequence of biofilm in dental unit waterlines



# Biofilm in GP/dental office II.

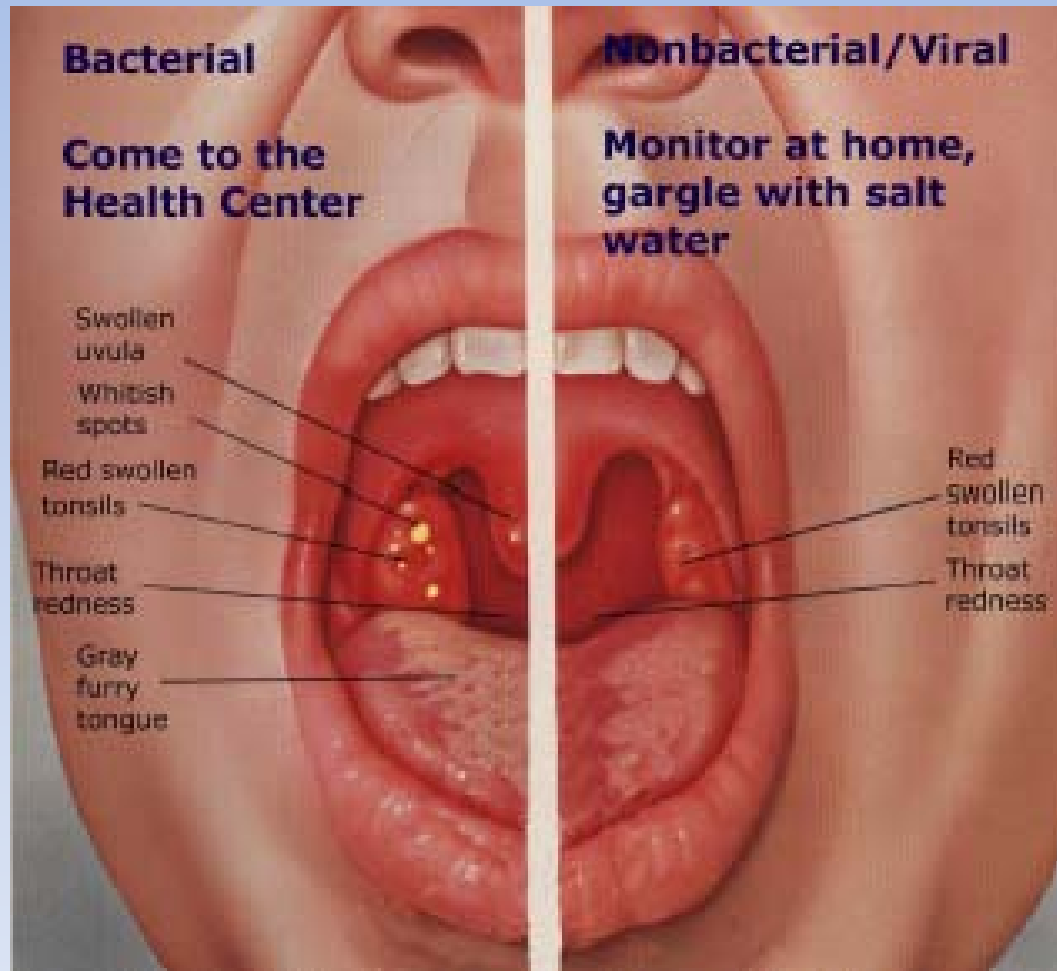
- Microbes found in waterlines in significant concentrations
  - Pseudomonads
  - Legionellae
- Evidence suggests exposure of patients and dental staff to potential bacterial pathogens via dental unit waterlines

# Biofilm in GP office III.

- No efficient way of controlling biofilms
- Main interim recommendation
  - Run water for several minutes at the beginning of each clinic day
  - Run high-speed handpieces for 30 seconds after use on each patient
  - 60°C waterlines treatment

# Infections manifested in oral cavity

# Overview



# Viroses in oral cavity I.

- HSV
- Primary infection on small children
  - Inaparent
  - Older children – gingivostomatitis
    - Acyclovir
    - Dentists - paronychium



# Viroses in oral cavity II.

- VZV – chickenpox
  - Rapidly bursting vesicles, erythrema on the palate & uvula
  - Herpes zoster – pain similar to teeth pain
- EBV
  - Small petechia on the borders of soft and bony palate, pharyngitis, pseudomembranous tonsillitis, pronounced neck lymphadenitis
  - Edema of Waldeyer lymphatic bow
  - In HIV specific – hairy leukoplakia

# Viroses in oral cavity III.

- HHV 6
  - Exanthema subitum
  - Erythrematous papuli
- Coxsackieviruses
  - Herpangina – ulcerative lesions on tonsils, soft palate and uvula, similar to herpetic, 1-2 mm, grayish surface, surrounded by erythema

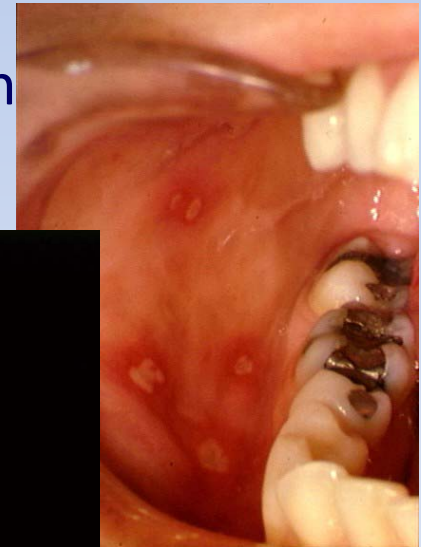
# Viroses in oral cavity IV.

- Morbilli
  - Prodromal period – Koplik's marks

Koplik's marks



Hand-foot-mouth disease



Hairy leukoplakia



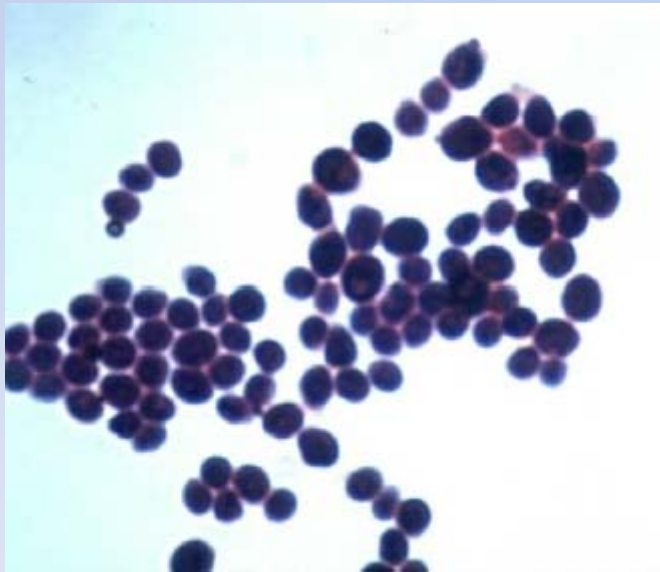


# HIV

- First indicator – mycotic infections
- Viral infections
- Bacterial infections
- Cervical lymphadenopathy and lymphomas

# Mycotic infections

- Oral candidosis – opportunistic pathogen
- Treatment – local ATM, autovaccines



# Mycotic infections

- Pseudomembranous candidosis – soor
- Erythrematous (atrophic) candidosis
  - *Acute*
  - *Chronic*
- Hyperplastic candidosis
- Angular candidosis

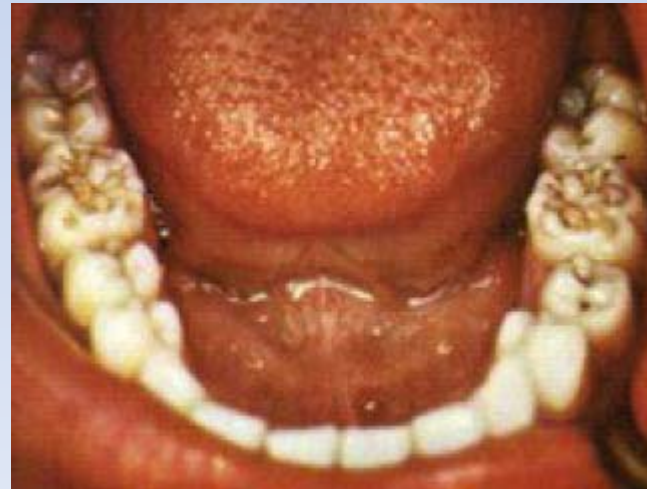
# Bacterial infections I.

- Gonorrhoea
- Scarlatina



# Bacterial infections III.

- Syphilis
- Late congenital
  - Hutchinson's teeth
  - Hard palate defect
  - Fournier teeth



# Bacterial infections II.

- Diphtheria
  - Pseudomembranous tonsillitis or laryngitis

