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PPT Presentation

Biofilms as a Source of Pathogenicity

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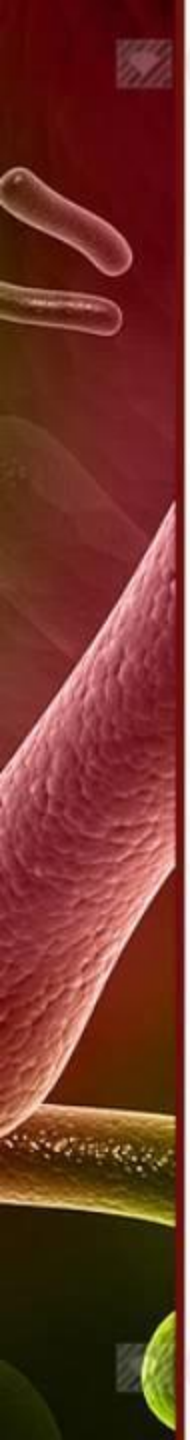


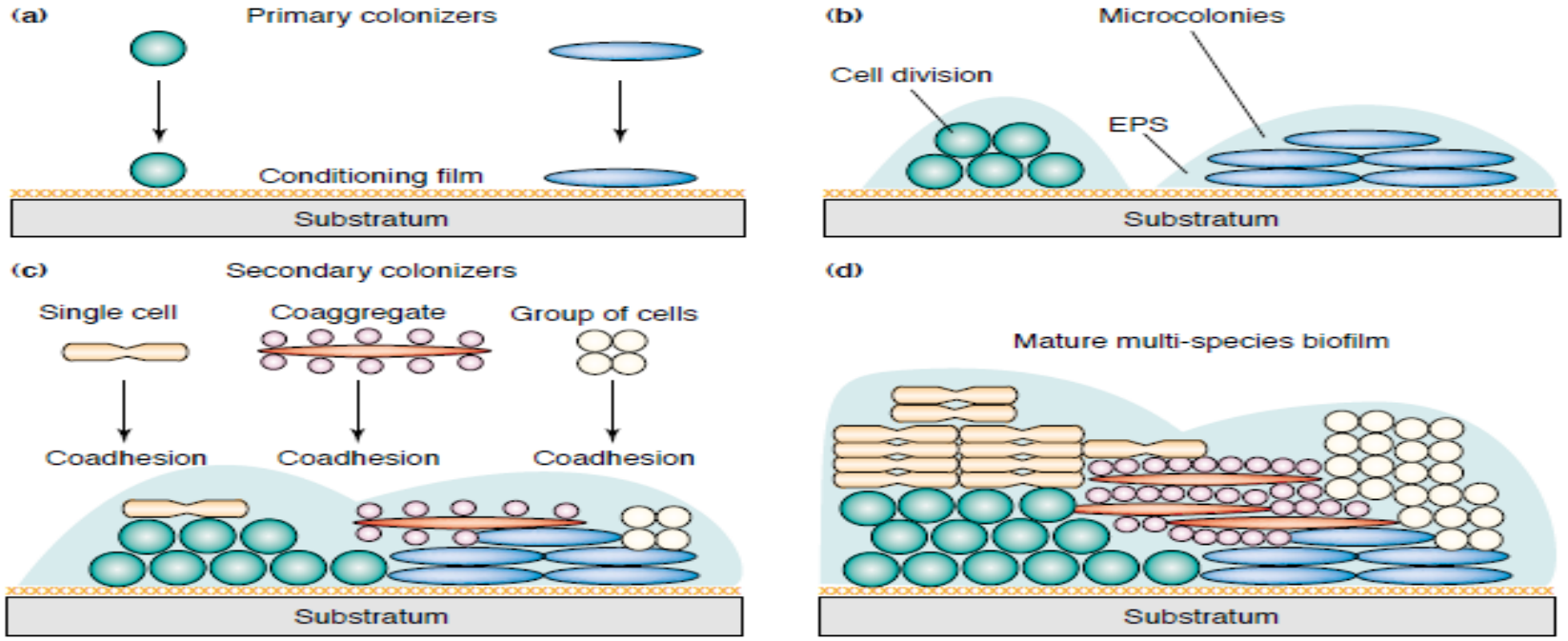
Biofilms

- Microbial ecology: Interactions of microbes with both biotic and abiotic environments
- Constitute micro-ecosystems that are filled with hundreds of other microorganisms
- Where the adherent microbial cells are encased within a self-produced matrix of extracellular polymeric substances jumbled with proteins, carbohydrates and/or DNA
- Such surface-attached communities are referred as biofilms

Biofilms in Nature

Biofilms in nature exist as

- Single species biofilms
- Multispecies consortia

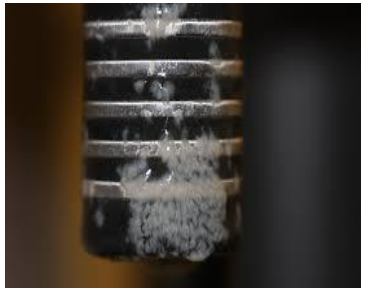


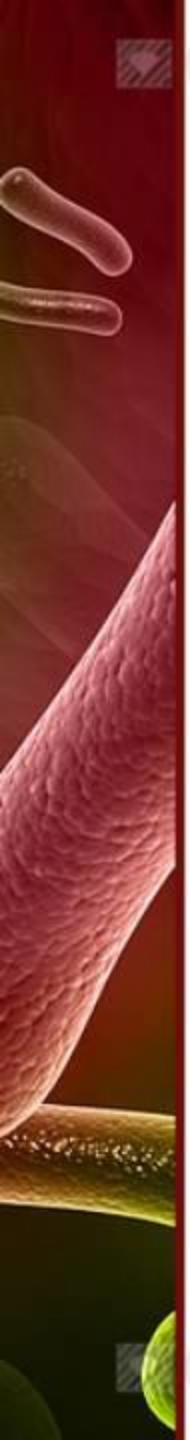
Multispecies biofilms (Source: Rickard, 2003)

Biofilm Occurrence

Biofilms as slime cities thrive wherever is there is moisture

- In kitchen
- On contact lenses
- In gut linings of animals
- On medical implant materials
- Food products
- Pipelines, rocks and sediments submerged in streams
- Separation membranes and filters etc.

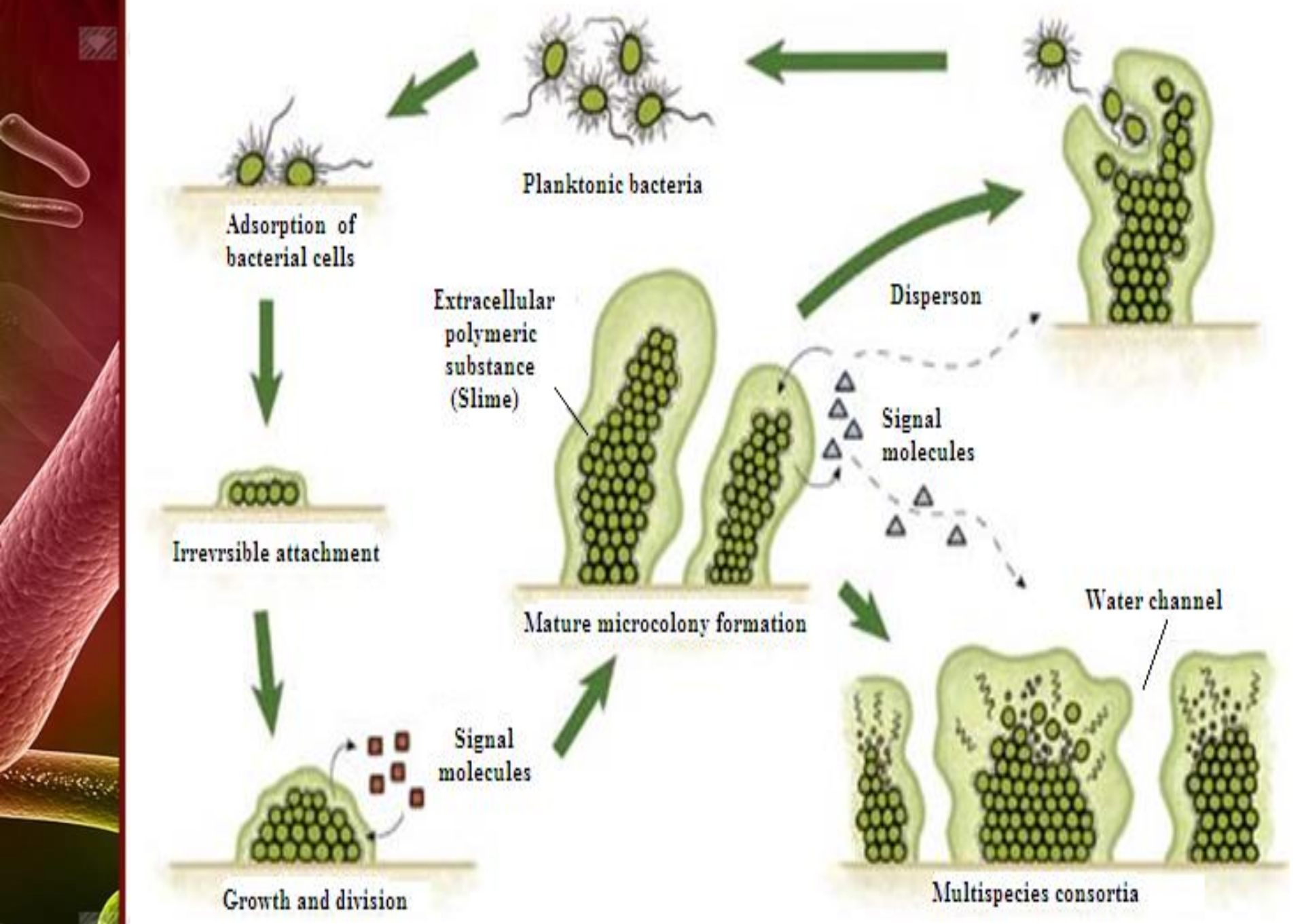




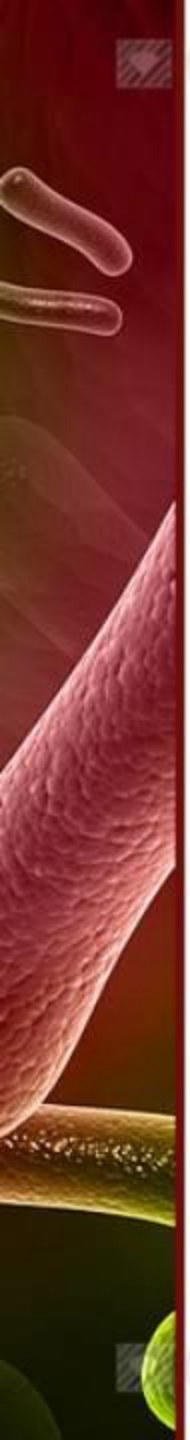
Formation of Biofilms

Biofilm development occurs in different sequential phases including

- Surface conditioning by adsorption of nutrients
- Reversible and irreversible attachment of bacterial cells on to the surface
- Surface colonization
- Degeneration and dispersal of organisms to colonize new niche to form a new biofilm



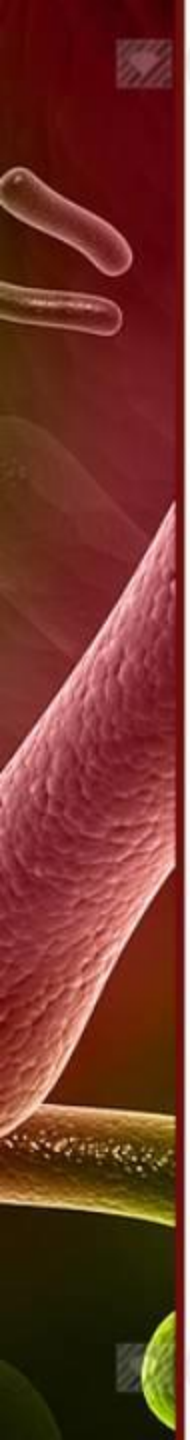
Developmental phases in biofilm formation (Source: Harrison *et al.*, 2005)



Biofilms Supports Microbial Growth

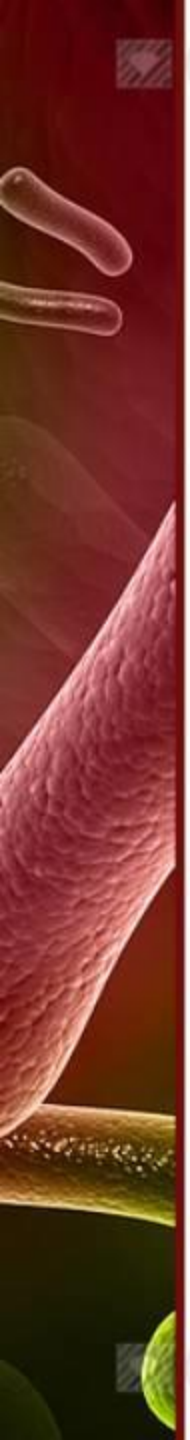
Biofilm mode offers their member cells

- Higher genetic transformation frequencies
- Maintenance of extracellular enzyme activities
- Protection from a wide variety of toxins and antimicrobial factors
- Shelter against predation and hostile environments



Factors Influencing Biofilm Formation

- Nutrient availability
- Chemotaxis towards the surface
- Surface adhesins
- Presence of other microbial species
- Presence of surfactants
- Seasonal variations
- Quorum sensing

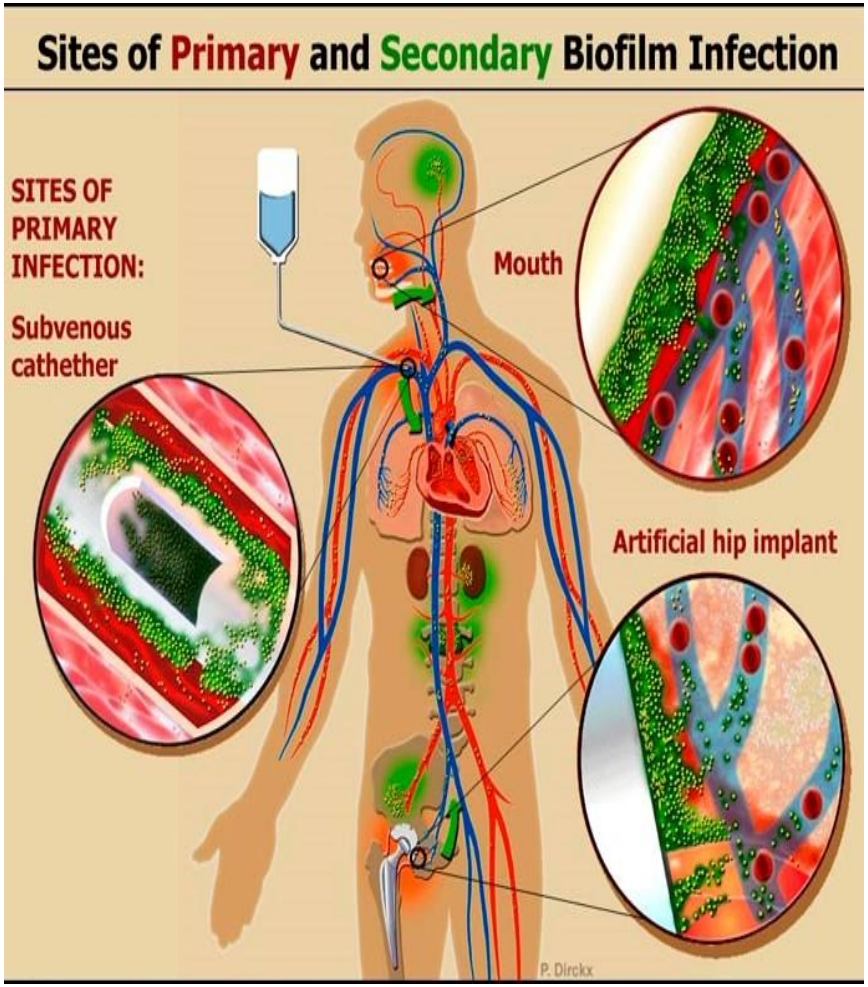


Biofilms: Potential Source of Pathogenicity

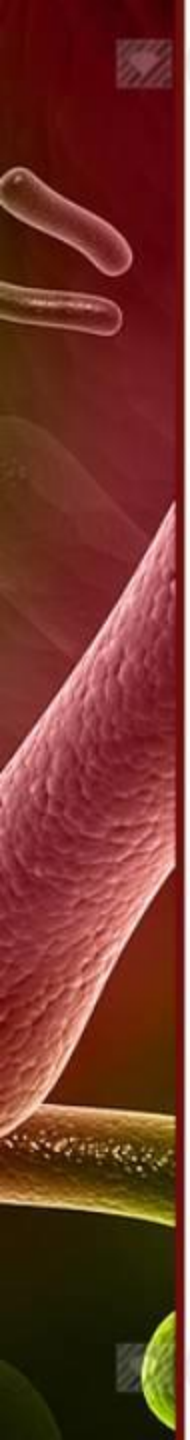
From medical perspective biofilms and biofilm associated microbes are of great concern as they posses the capability of causing serious infections

Biofilms: Major Cause of Nosocomial Infections

- Evidences suggest biofilms cause a variety of nosocomial (hospital-acquired) and chronic infections
- Center for Disease Control estimates that over 65% of nosocomial infections are caused by biofilms



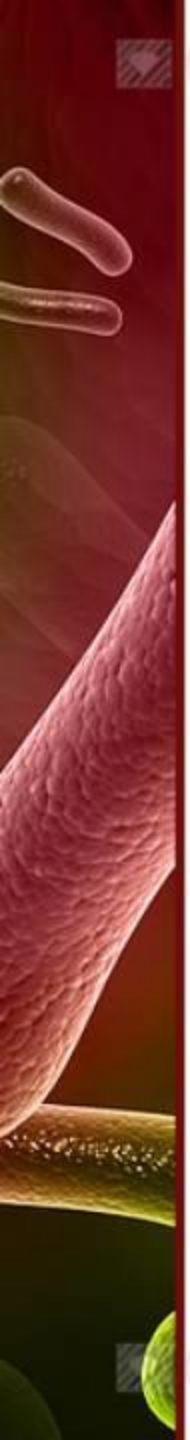
Common sites of biofilm infection (Source: Center for Biofilm Engineering, Montana State University-Bozeman)



Clinical Characteristics during Disease Processes

Characteristics of biofilms that can be important in infectious disease processes include

- Cells aggregation which results in blood stream or urinary tract infections or in production of emboli
- Exchange of resistance plasmids by cells within biofilms
- Reduced susceptibility of cells to antimicrobials within biofilms
- Production of endotoxins by biofilm associated microbes
- Resistant to host immune systems

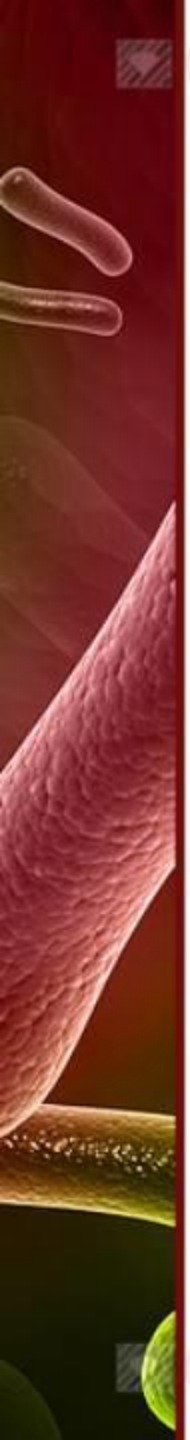


Biofilms on Indwelling Medical Devices and Prostheses

- A significant number of people are affected by biofilm infections which develop on medical devices implanted in body such as catheters (tubes used to conduct fluids in or out of body), artificial voice prostheses, artificial joints, mechanical heart valves, pacemakers and other surgical implants
- Colonization of implanted materials by microorganisms results in slow developing but persistent infections
- Moreover, prevalence of such infectious disease is expected to increase with increasing use of such devices in modern practice of medicine
- Thus biofilms and biofilm associated microorganisms are becoming a growing concern in modern medicine

Prosthetic joint infections (Source:www.antimicrobe.org)

Biofilm infections transmitted via heart devices (Source: www.mayo.edu)

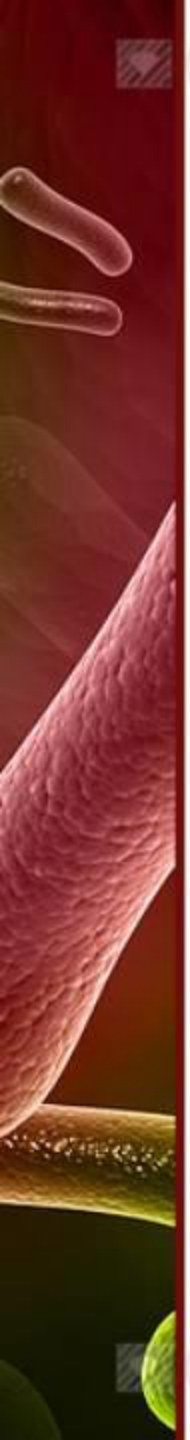


Biofilm Pathogens on Implants

Biofilms on indwelling medical devices may be composed of

- Bacteria including *Enterococcus faecalis*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus viridians* (gram-positive), *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus mirabilis* and *Pseudomonas aeruginosa* (gram-negative)
- Yeasts including *Candida albicans* and *Candida parapsilosis*

Once developed on indwelling medical devices these biofilms are difficult to remove because being highly resistant to antibiotic treatment

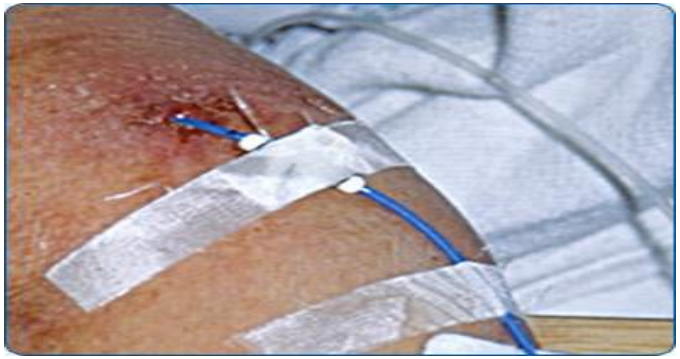


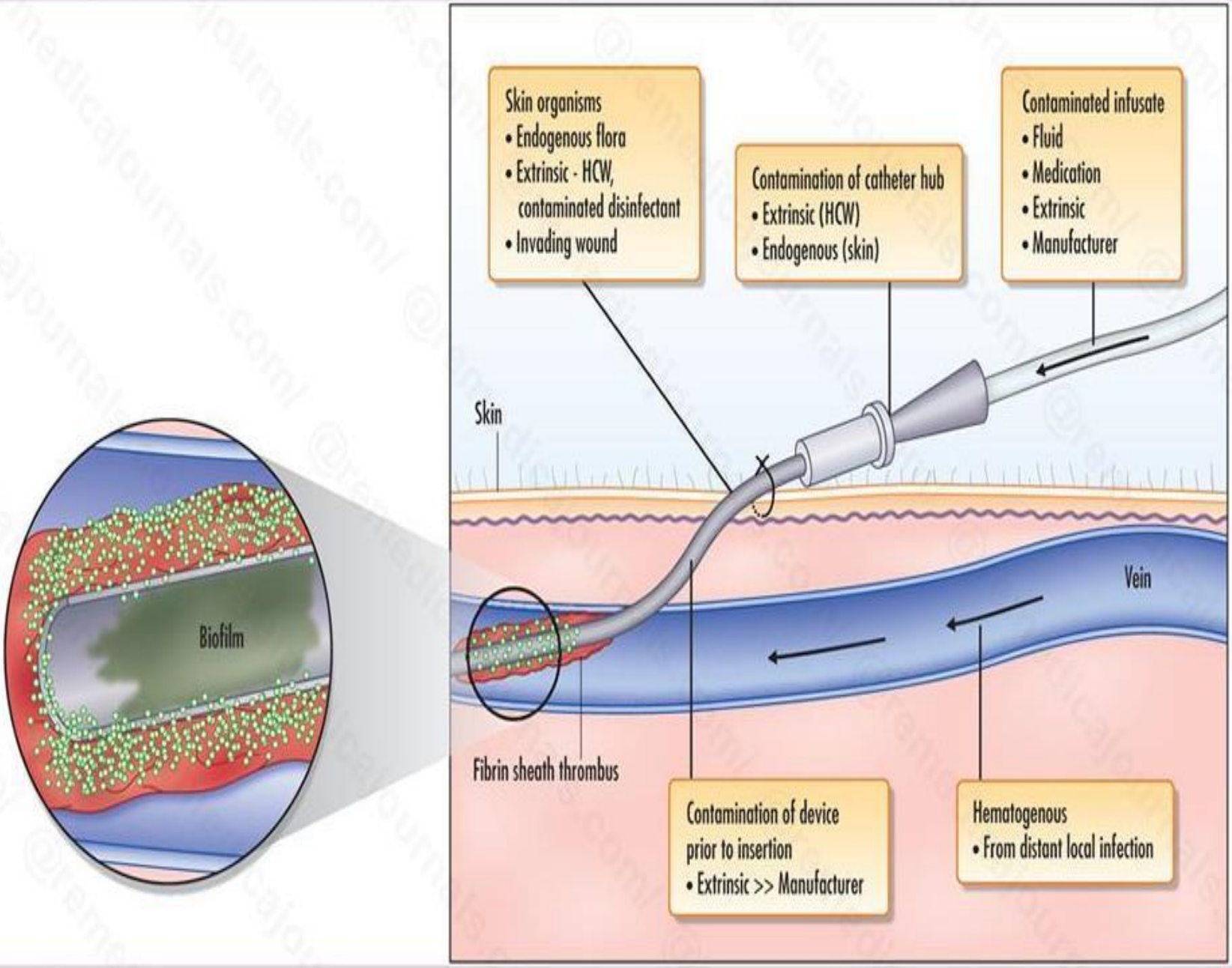
Endocarditis and Biofilms

- Microorganisms have a greater tendency to attach and develop biofilms on components of mechanical heart valves and surrounding tissues of heart, thus leading to a condition known as prosthetic valve endocarditis.
- Primary organisms responsible for this condition are *S. epidermidis*, *S. aureus*, *Streptococcus* sp., gram-negative bacilli, diphtheroids, enterococci and *Candida* sp.
- These organisms may originate from skin, other indwelling devices such as central venous catheters, or dental work

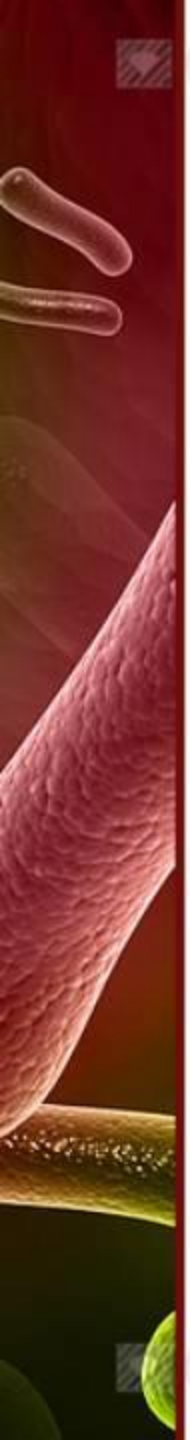
Central Venous Catheters and Biofilms

- These catheters are inserted for administration of fluids, nutritional solutions, medication, blood transfusion and hemodynamic monitoring
- Most common microbes isolated from catheter biofilm are *S. epidermis*, *S. aureus*, *P. aeruginosa*, *K. pneumoniae* and *C. albicans* etc.
- These organisms originate either from skin microflora of patients or exogenous microflora from health-care personnels



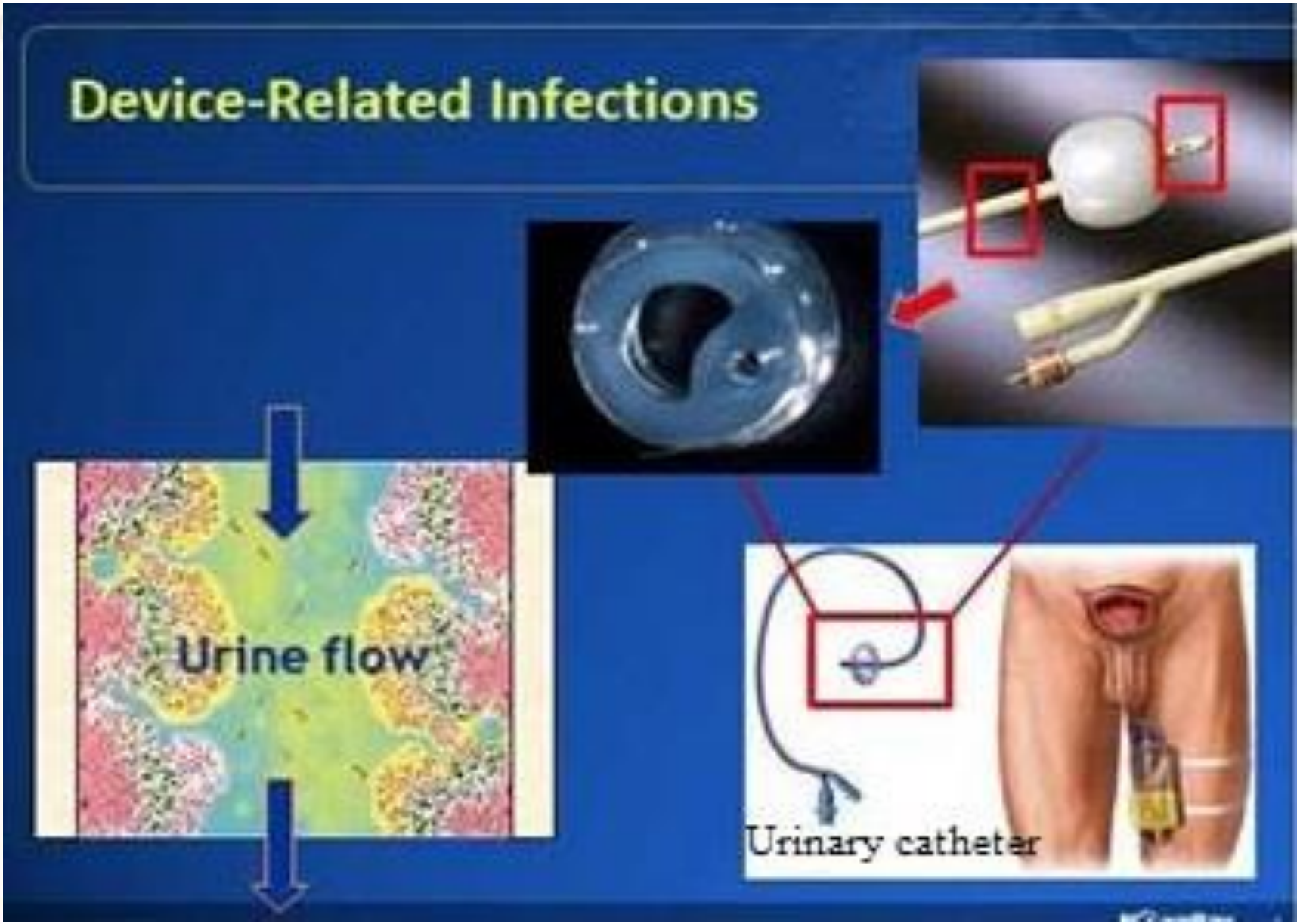


Intravenous catheter with biofilm growth (Source: James *et al.*, 2011)

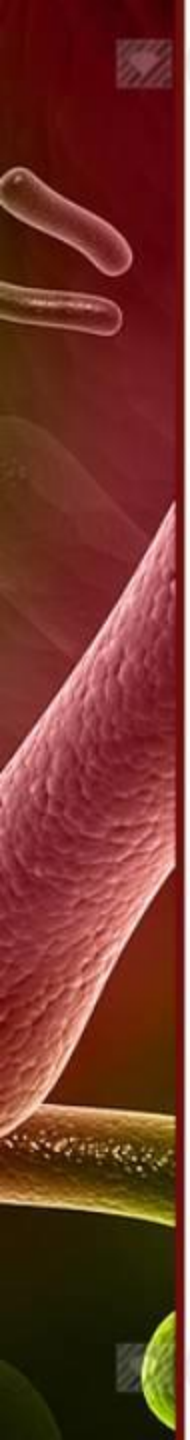


Urinary Catheters and Biofilms

- Urinary catheters are tubular latex or silicone devices inserted into bladder to monitor urine output and urine collection during surgery
- When inserted may readily acquire biofilms on inner or outer surfaces
- Catheters may be
  - Open system (drainage of catheter in an open collection centre), quick contamination of catheter resulting in urinary tract infections (UTIs)
  - Closed system (drainage of catheter in secure fastened plastic bag), patients with this system are less prone to UTIs



Catheter-associated urinary tract infections caused by biofilms (Source: smithonstocks.com)

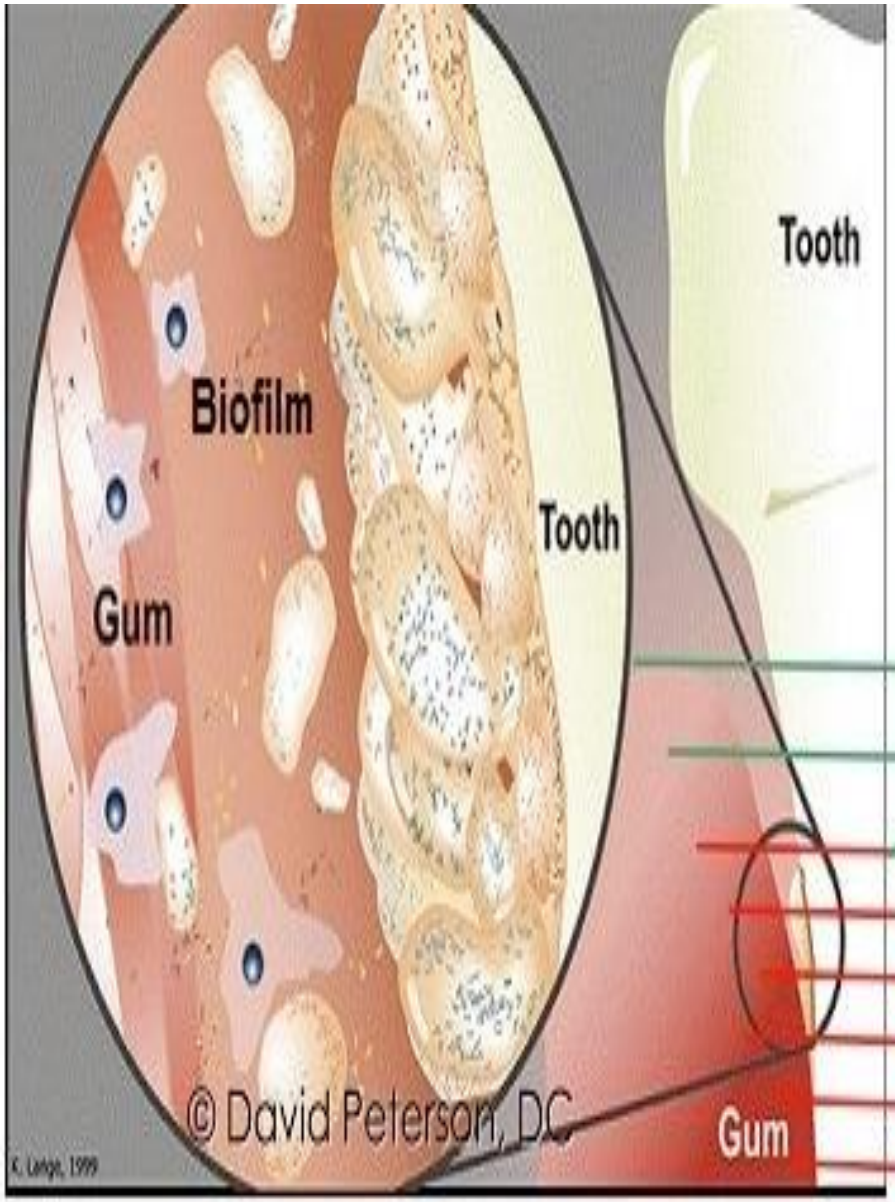


Biofilm Pathogens on Catheters

- Organisms commonly contaminating these devices and developing biofilms are *S. epidermidis*, *Enterococcus faecalis*, *E. coli*, *Proteus mirabilis*, *P. aeruginosa*, *K. pneumoniae* and other gram-negative organisms
- Longer the urinary catheter remains in place, the greater will be the tendency of these organisms to develop biofilms and result in urinary tract infections

Biofilms and Dental Plaque

- Dental plaque refers to a yellowish biofilm that builds up on teeth
- Dental plaque formation includes a series of steps beginning with initial colonization of pellicle till formation of complex mature biofilms
- If not removed regularly, it may cause dental caries while in extreme



Primarily Aerobic Bacteria

- 1-2 mm pocket and/or surface of tooth:
- Acid loving
- Cariogenic (Cavity causing)

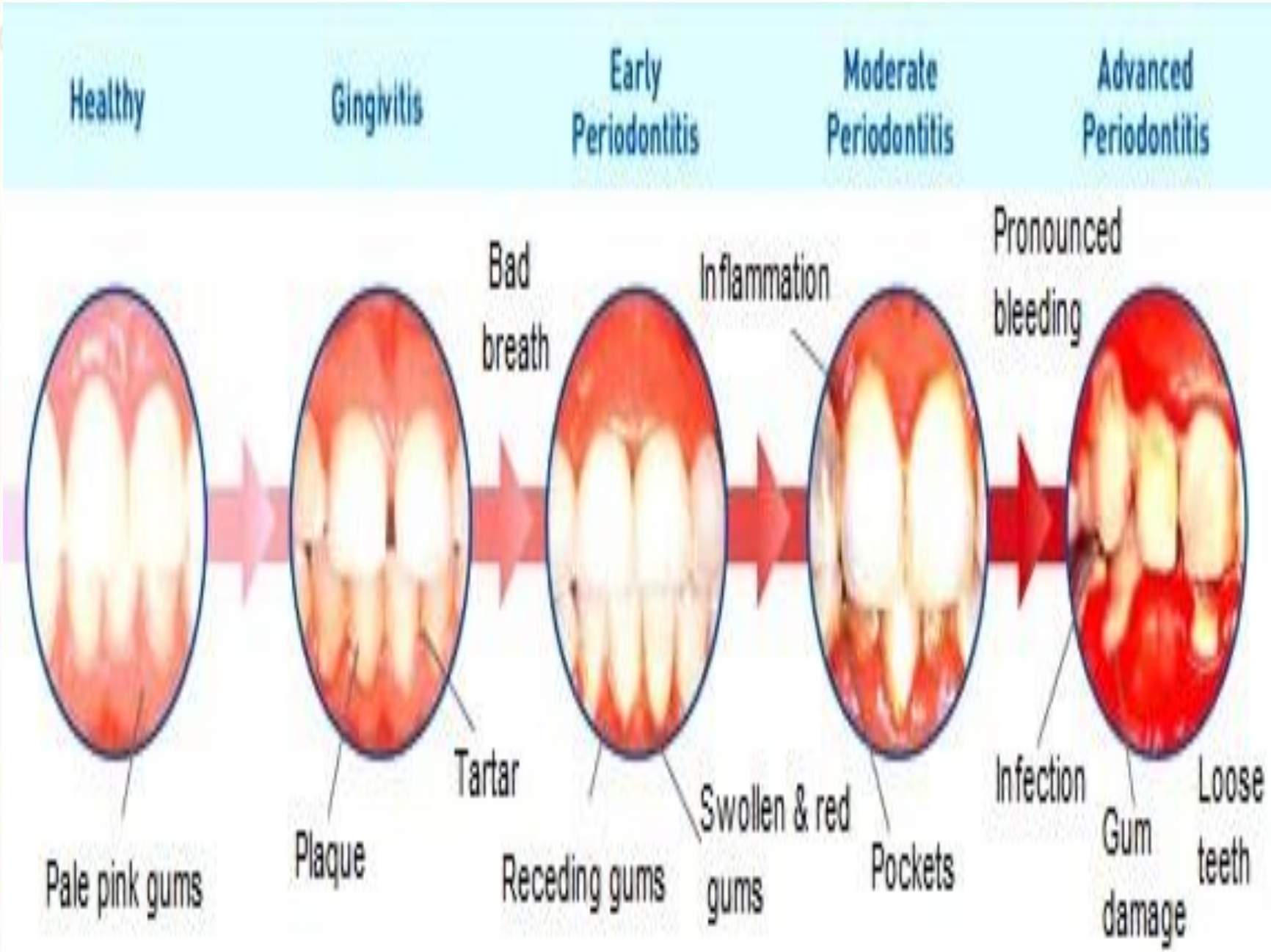
1-2 mm Transitional area

- Aerobic to Anaerobic Bacteria

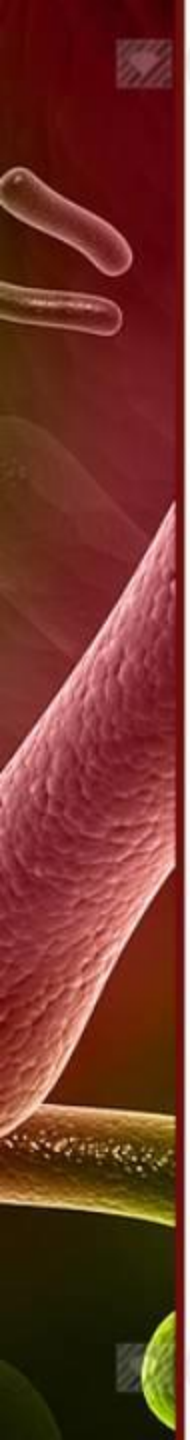
Primarily Anaerobic Bacteria

- 3 or greater mm pocket:
- Alkaline loving
- Periogenic
  - (Periodontal disease or gingivitis)

Biofilm formation in oral cavity (Source: www.wellnessalternatives-stl.com)

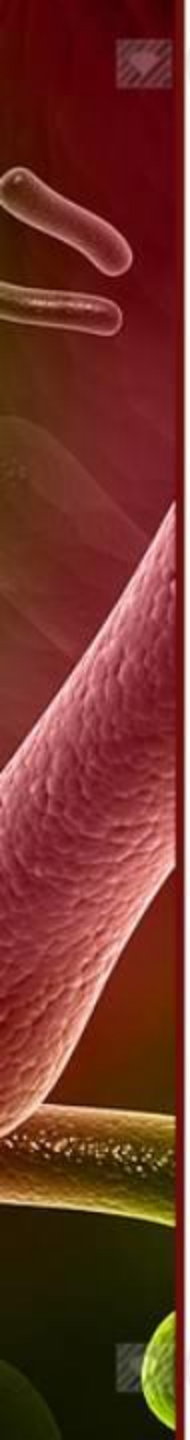


Progression of untreated periodontal disease (Source: www.smileatl.com)



Pathogens Associated with Periodontitis

Main microbe associated with periodontitis is *Porphyromonas gingivalis* while other organisms may include *Fusabacterium nucleatum*, *Eubacterium timidum*, *Pseudomonas anerobicus* etc.

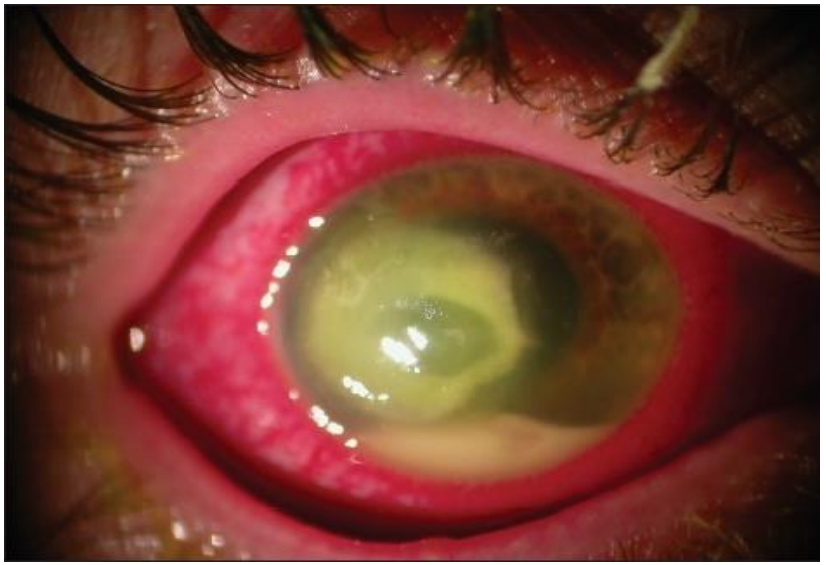


Contact Lenses and Biofilms

- Presence of bacterial biofilms has been demonstrated on materials relevant to eye such as contact lenses, scleral buckles, suture material and intraocular lenses
- Many ocular infections often occur when such prosthetic devices come in contact with or are implanted in eye
- Biofilm formation on contact lenses and contact lens storage cases may be a risk factor in contact lens-associated corneal infections.
- Studies have shown that contamination of lens cases by bacteria, fungi and amoebae is common among 20-80% of lens wearers with a contaminated lens case

Biofilm Pathogens Adhering to Contact Lenses

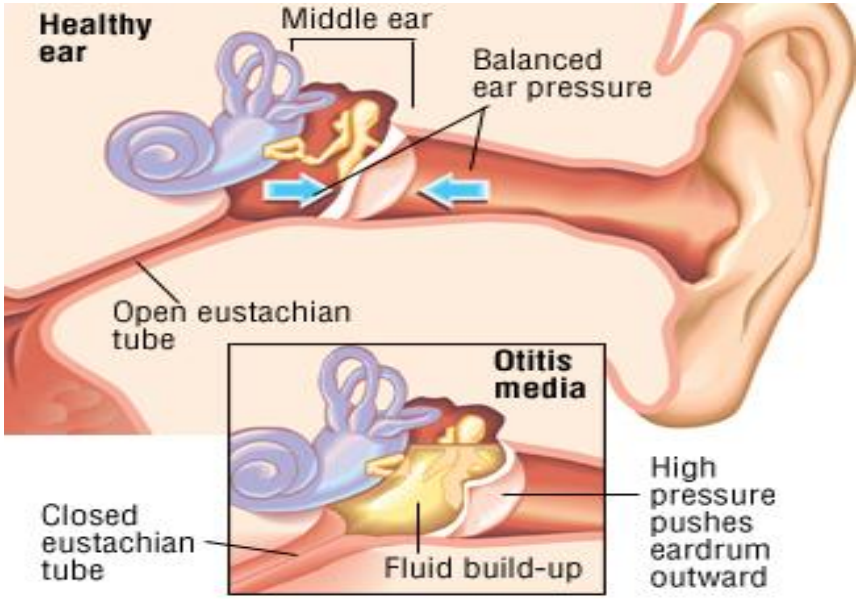
- Adherent organisms include *E. coli*, *P. aeruginosa*, *S. aureus*, *S. epidermis* and certain species of *Proteus*, *Serratia*, *Candida* etc.
- These organisms may lead to keratitis

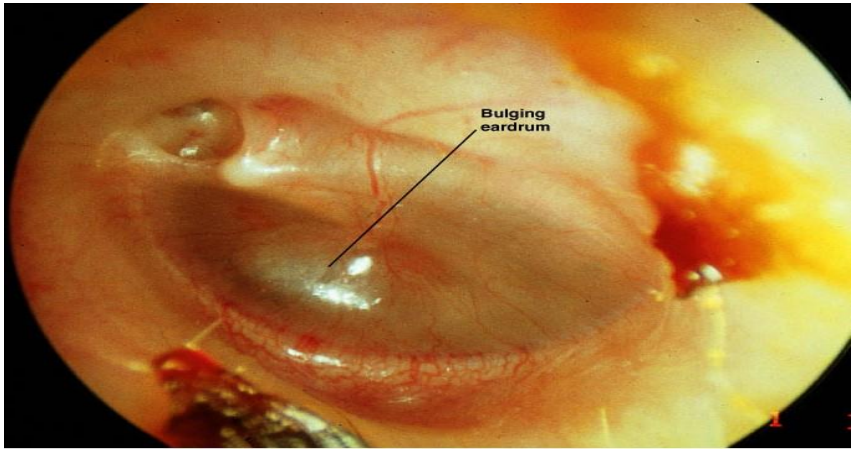


Contact-lens related keratitis (Source: www.ophthalmologymanagement.com)

Biofilms and Otitis media

- Otitis media a chronic ear infection involves inflammation of mucoperiosteal lining
- The infection is caused by a number of different organisms including *S. epidermis*, *Haemophilus influenzae*, *Moraxella catarrhalis*, *P. aeruginosa* etc.

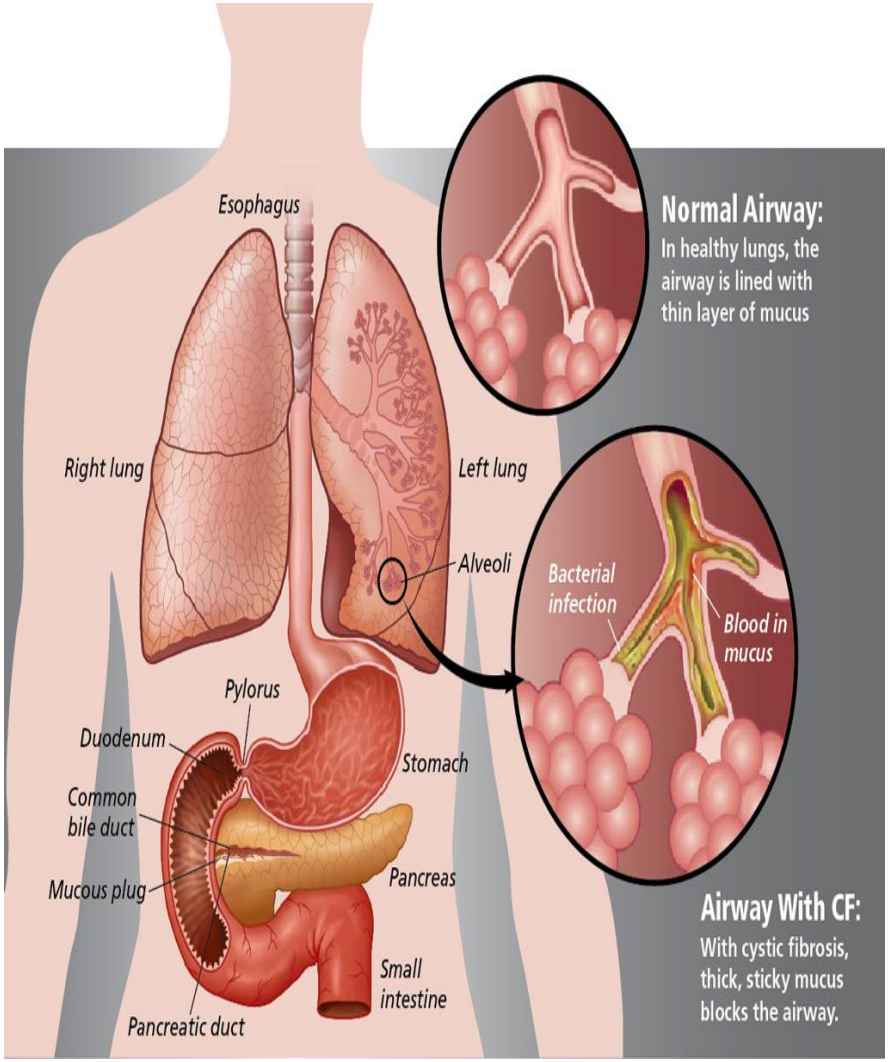




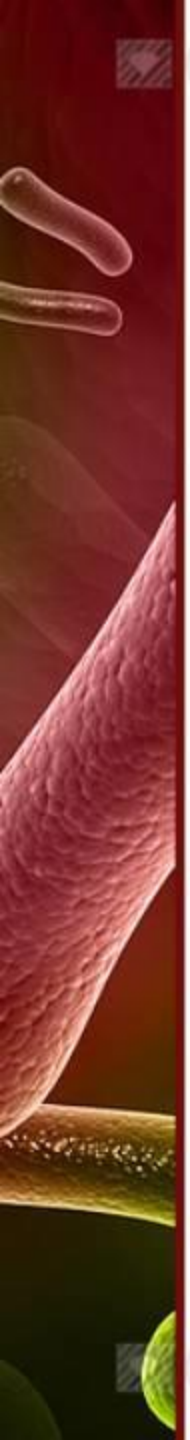
Ear infection by biofilm growth (Source:imgarcade.com)

Cystic fibrosis and Biofilms

- Cystic fibrosis a chronic lower respiratory tract infection
- *S. aureus*, *H. influenzae* infections usually predispose cystic fibriosis affected lungs to colonization by *P. aeruginosa*



Biofilms in cystic fibrosis (Source: discovermagazine.com)



Food Industry and Biofilms

- Growth of biofilms in food processing environment leads to increased opportunity for microbial contamination of processed food, thus causing serious hygienic problems and economic losses due to food spoilage

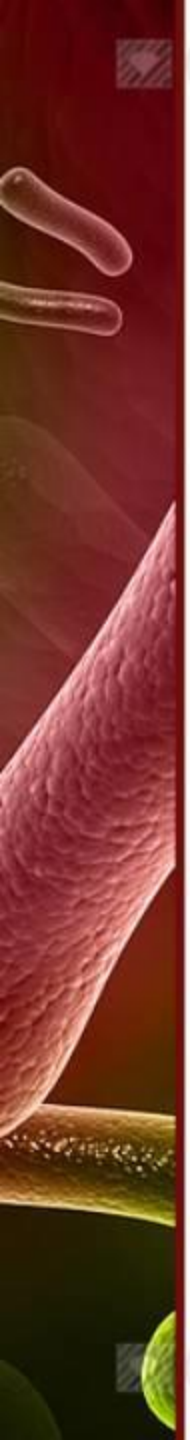
- Biofilms are most commonly encountered in dairy industry mainly due to improper sanitization of processing equipment

Pathogens on Food Contact Surfaces

Food-borne pathogens include *Listeria monocytogenes*, *Campylobacter jejuni*, *Escheriachia coli*, *Yersinia enterocolitica*, *Streptococcus thermophilus* etc.

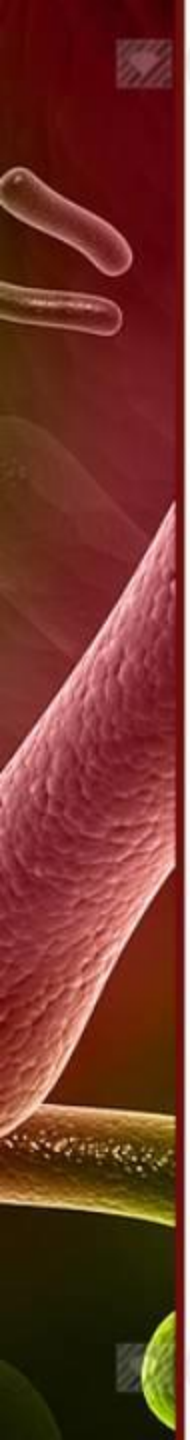
Biofilms and Water Quality

- Biofilms in portable water distribution systems deteriorates the water quality
- Enteric pathogens such as *L. pneumophila*, non-tuberclosis mycobacteria, *Helicobacter pylori* are commonly harbored by biofilms
- These are introduced into distribution network from external sources via open reservoirs, breakage during construction of new pipelines etc.



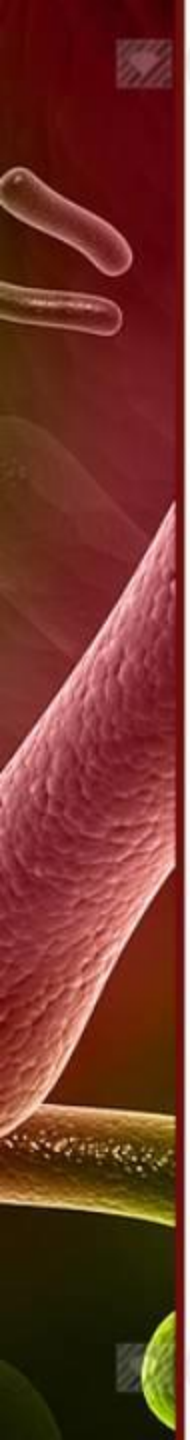
Biofilms and Antibiotic Resistance

- Microorganisms growing in a biofilm are highly resistant to antimicrobial agents and/or antibiotics
- They appear to be more resistant (up to 1,000 times) than the same microbe not growing in a biofilm mode
- As within biofilms individual microorganisms are bound together by a polymeric substance excreted by the microorganisms. This protective encapsulation is believed to play a key role in some of the antibiotic-resistant infections
- The standard antibiotic therapy often seems to be useless as cells possessing natural resistance may survive and grow even at higher concentrations of antimicrobial agents



Biofilms and Disinfectants

- Disinfectants such as chlorine, chloramines, ozone, hydrogen peroxide are applied for eradication of biofilms
- However, use of disinfectants enhances formation of easily biodegradable substances which can be utilized by microorganisms as a source of energy thus promote biofilm formation
- Failure of conventional treatment processes spurge the development of new control strategies



Green Strategies for Biofilm Control

- Use of green chemicals such as enzyme based detergents or biocleaners
- Use of phages for controlling biofilms
- Bioregulation i.e. control of biofilms through microbial interactions /metabolite molecules seems to be a viable option in overcoming the biofilm resistance issues

References

- Harrison JJ, Turner RJ, Marques LLR, Ceri H (2005) Biofilms: A new understanding of these microbial communities is driving a revolution that may transform the science of microbiology. American Scientist 93: 508-515.

- Rickard AH, Gilbert P, High NJ, Kolenbrander PE, Handley PS (2003) Bacterial coaggregation: an integral process in the development of multi-species biofilms. Trends Microbiol 11: 94-100.

- James H, Ghannoum M, Jurevic R (2011) The story of biofilms. J Invasive Fungal Infect 5(2): 37-42.