BIOFILMS

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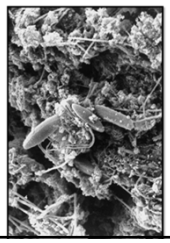
OBJECTIVES

1. Describe biofilms.
2. Discuss the infections associated with biofilms.
3. Identify problems with treatment and prevention.

WHAT ARE BIOFILMS?

- Communities of organisms attached to a solid surface
  - Can be nonliving or living tissue surface
- Evolve over time consisting of many species
- Embedded in extracellular matrix
- Located at phase interface—flow
- Most important, they are a multiorganism cooperative population
- In nature 95-99% of microbes in biofilms



EXAMPLES OF BIOFILMS

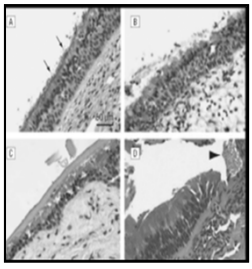
- Water pipes
- Ventilator system of airplanes or convention centers
- Wine casks causing spoilage
- Serious lung infections of cystic fibrosis (CF) patients

DENTAL UNIT WATER LINES

- Legionella spp.
- Nontuberculous Mycobacteria (NTM)
- Pseudomonads
- Grow and multiply in biofilm to reach infective concentrations
- Potential for inhalation leading to respiratory infections
- Direct contamination of surgical wounds

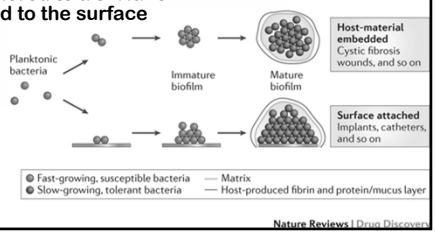
BIOFILMS

- Account for over 80% of microbial infections in the human body (NIH)
- 17 million new biofilm infections with 550,000 fatalities each year
- Chronic infections and longer hospital stays



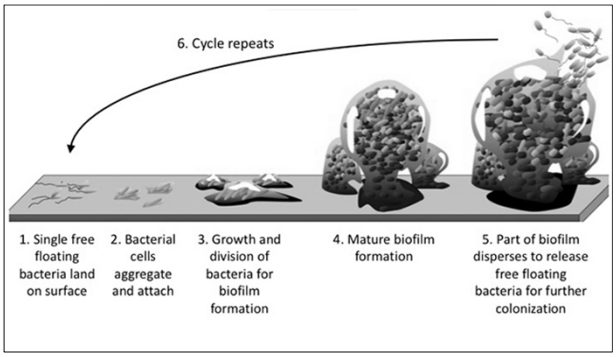
BIOFILMS

- Protect from oxygen & other harmful factors
- Two main types of biofilms
- Sessile
  - Permanently anchored to a surface
  - Covalently bonded to the surface
- Planktonic
  - Free floating
    - Movement to new habitats



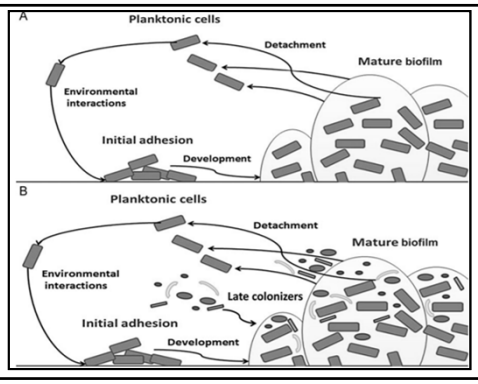
STEPS

- Single cell layer--initial attachment to an abiotic or biotic surface
  - Production of reversible adhesion—living or dead
- Maturation of the biofilm
  - Irreversible adhesion—can move at first but lose motility and adhere to each other and excrete matrix to become microcolonies
  - Secondary colonizers become attached and pores, cavities, channels, outgrowths form
- Dispersal
  - Disintegration, degradation, loss, liberation—single cells or microcolonies



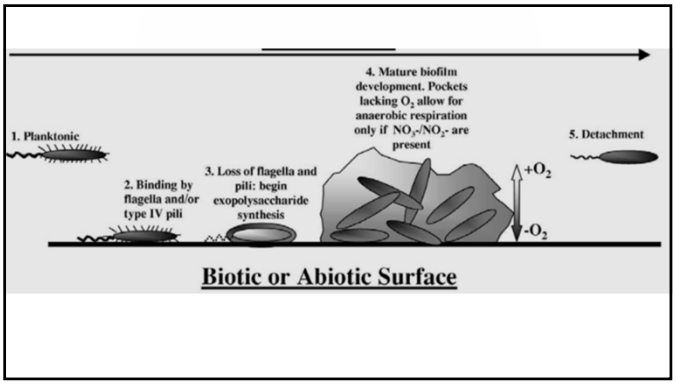
STRUCTURES

- Primitive-simple cell layer
- Mats of photosynthetic, methanogenic, and sulfate reducing communities (waste water)
- Dental biofilms (plaques) a complex community of many microorganisms and hundreds of species
- Bandlike outgrowths, formed by mixed bacterial populations under conditions of turbulent flow—torn off & disseminated
- Mature—3 dimensional structure with pores, channels, voids, signal components of "quorum sensing" system

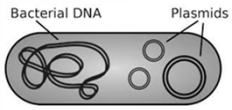


ARCHITECTURE

- Outer layer
  - Most dynamic and metabolically active cells
- Intermediate layer
  - Still active but less so
  - Genetic reservoir for genes involving nutrient utilization and drug resistance
- Inner surface layer
  - Persister cells
- Allow growth in hostile environment--stress

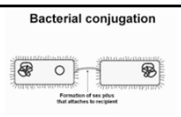


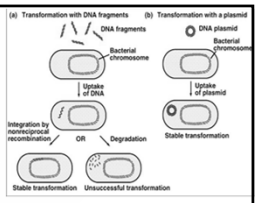
GENETICS



- Exchange of genetic information high
- Scanning confocal laser microscopy—reporter gene encode fluorescent to see plasmids
- Microarrays for mRNA demonstrate differences in planktonic and embedded species

GENETICS

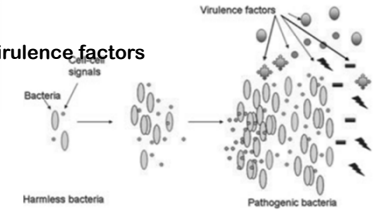




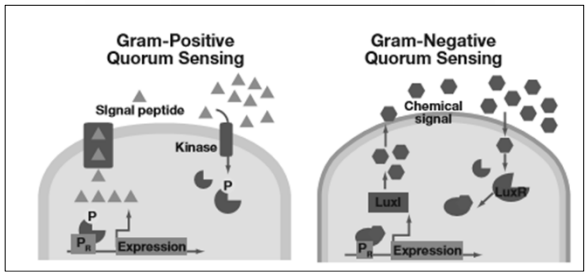
- Gene transfer
  - Transformation
  - Conjugation
- Greater genetic potential as a group than alone
  - Eventually the virulence factors cluster, causing a worsening of disease.
- Disaggregation
  - Potential to transmit already upregulated resistant aggregates of microorganisms to other body sites

ROLE OF QUORUM SENSING

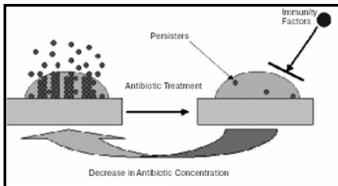
- Cell communication widely used to coordinate expression of traits once a population threshold is reached
  - Metabolism
  - Production of multiple virulence factors
  - Chemotaxis
  - Biofilm formation
  - Swarming motility



PHEROMONES

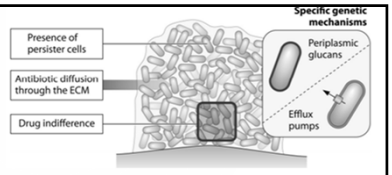


PERSISTERS



- Metabolically inert cells present in all biofilms
- Disabled apoptosis
- Maintain gene pool
- Resist environmental stress (antimicrobials)

RECALCITRANCE

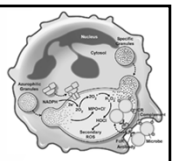


- Survival after physicochemical aggression
  - UV light, heavy metals, acidity, changes in hydration or salinity, and phagocytosis
  - Withstand antibiotic-mediated killing even when planktonic cells are susceptible

RECALCITRANCE

- Impaired antibiotic diffusion—subinhibitory levels
  - Increases resistance
  - Increases mutations through conjugation
  - Rearrangement of integrin gene cassette
  - Increases persisters
- Hypermutability—60-fold higher in *S.aureus*
  - Induces breakage in DNA
  - Down-regulates repair genes
- Small-colony variants
  - Better piliation, adhesion, adherence to cells

RESISTANCE TO IMMUNE SYSTEM



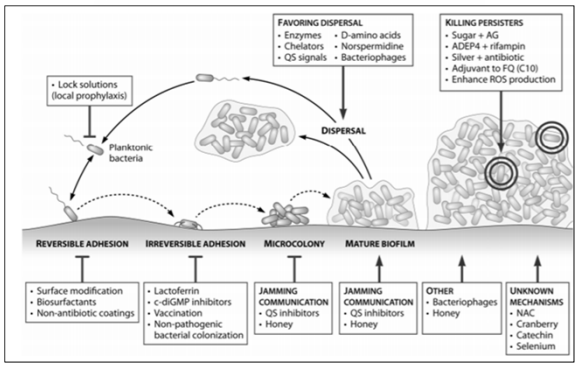
- Matrix act as decoy molecules that prevent efficient microbial recognition by neutrophils
- Impaired oxidative burst and neutrophil killing
- Conceals b-glucans from recognition by innate immune pattern recognition receptors
- Protects from neutrophil extracellular traps (
- Down-regulation of flagellin expression and motility because flagellin is a ligand for Toll-like receptor
- Motility facilitates host cell invasion and phagocytosis

PREVENTATIVE STRATEGIES

- Hygiene, training, reduction in devices
- Removal of unnecessary devices
- Antibiotic prophylaxis during insertion
- Antibiotic coating—local high concentration
- Mechanical removal

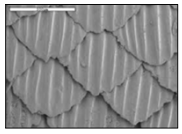
OPTIMIZATION OF ANTIMICROBIALS

- Choose best antimicrobial for organism
- Lock solutions for catheters—12 hours high concentration antimicrobials
  - High risk patients
  - Can prevent blood stream infections
  - With systemic antimicrobials if not removed
  - Must remove catheter if *S. aureus* or *Candida*



PREVENTIVE STRATEGIES

- Inhibiting adhesion
  - Material modifications and biosurfactants
    - Zirconium oxide rather than pure titanium implants
    - Silicon coating
    - Sharkskin pattern
    - Preventing protein and platelet adherence
    - Bioactive antibodies, mannose
    - Lactoferrin
    - Acoustic waves in urinary catheters



PREVENTIVE STRATEGIES

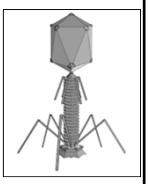
- Jamming quorum sensing
  - RNAIII-inhibiting peptide with *Staph. Aureus*
  - Azithromycin with *Pseudomonas aeruginosa*
  - Garlic and horseradish, green tea
- Vaccination to biofilm antigens
  - Before implantation
  - CF patients
  - Chronic UTI

ERADICATING BIOFILMS

- Antimicrobials
  - Up to 50% treatment failures, resistance, prolonged treatment
- Non-antimicrobials—alone or in combination
  - Inducing dispersal to return to planktonic state
  - Enzymes
  - Divalent cation chelators—EDTA & citrate
  - QS signals
  - *Bacillus subtilis*
  - NO

ERRADICATING PERSISTERS

- Aminoglycosides and mannitol or fructose
  - Stimulation of PMF leads to increased aminoglycoside uptake
- Silver--↑ membrane permeability to ↑effect of gentamicin, ofloxacin, or ampicillin
- Cocktail of bacteriophages

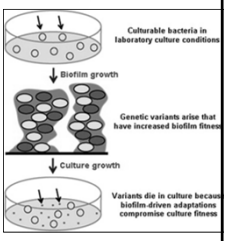


KEY CHARACTERISTICS

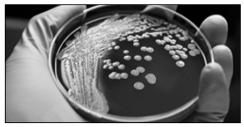
Key steps in surface-attached biofilm formation:	• Surface attachment to biotic and/or abiotic surface • Production of matrix including exopolysaccharide
Mechanisms to increase resistance to host defenses:	• Concealment or down-regulation of pathogen-associated molecular patterns or antigens • Resistance to phagocytic activity, host antimicrobial defenses, and NET killing
Mechanisms to increase resistance to antimicrobial drugs:	• Physiologic heterogeneity in biofilms, leading to subpopulations that are metabolically quiescent, slow growing, or that have induced stress responses • Limited diffusion or sequestration of antimicrobials by biofilm matrix • Increased expression of antimicrobial efflux pumps

WHY ARE OUR CULTURE PLANKTONIC?

- Rich media and optimal conditions
- Fast growing
- Biofilms protect from stress factors so organisms adapt phenotypically



LABORATORY CONSIDERATIONS



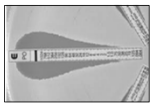
- Cultures
  - Require growth to get colonies
    - Problem is colonies won't grow under normal conditions
- False negatives
  - Improper sample collection
    - Swabs or culturing outer surface of equipment

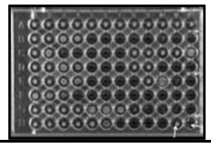
LABORATORY CONSIDERATIONS

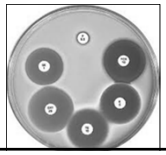
- Aggregates of organisms
  - Single colonies can represent up to 100,000 bacteria of mixed origin
  - Thus amounts of each organism are greatly underestimated or not considered significant

CULTURE AND SUSCEPTIBILITY

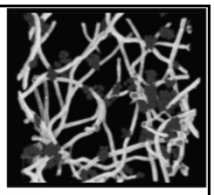
- Sonication of removed hardware to remove biofilm
- Antibiotic susceptibility
  - Single isolates that are members of a biofilm may not represent the genetic potential or resistance of a community







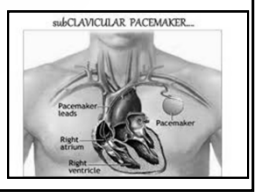
DETECTION

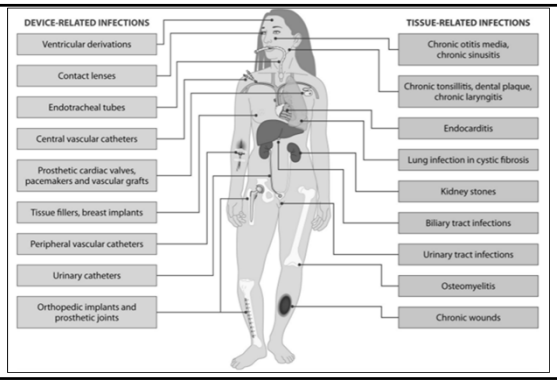


- Biopsies of tissue or removed device
- PCR
- Pathogen-specific probes
- Confocal laser scanning microscopic imaging

CHRONIC, DIFFICULT TO ERADICATE INFECTIONS

- Cystic fibrosis and *Pseudomonas aeruginosa*
- Indwelling medical devices with *Staphylococcus* and *Candida*



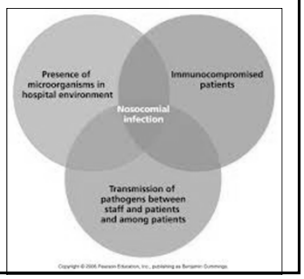


INDWELLING MEDICAL DEVICE-RISK RELATED INFECTIONS IN THE UNITED STATES

Device	Usage	Infection Risk (%)
Bladder catheter	Tens of millions	10-30
Cardiac-assisted devices	700	50-100
Cardiac pacemakers	400,000	1-5
Central venous catheters	5 million	5-8
Dental implants	1 million	5-10
Fracture fixators	2 million	5-10
Joint prostheses	600,000	1-3
Penile implants	15,000	2-10
Prosthetic heart valves	85,000	1-3
Vascular grafts	450,000	2-10

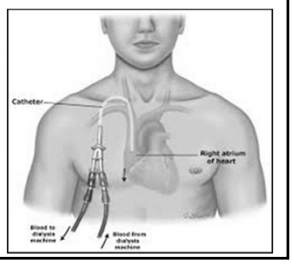
BIOFILMS: A MICROBIAL RESERVOIR FOR NOSOCOMIAL INFECTIONS

- **Hospital environment**
  - **Water distribution system**
  - **Contaminated surfaces**
  - **Biocides ineffective**
  - **Resistant to desication**



INDWELLING CATHETER–ASSOCIATED INFECTIONS

- **Central venous catheters in ICU**
- **↑cost, ↑length of stay, ↑mortality**
- **Skin commensals:**
  - **Coagulase negative staph**
  - ***Staphylococcus aureus***
  - ***Candida***
- **Removal necessary**

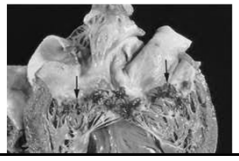


TREATMENT AND PREVENTION

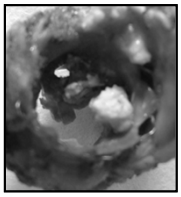
- **Surface coatings**
  - **Antimicrobials**
  - **Metal (silver, bismuth) nanoparticle**
- **Disruption of biofilm--removal**
- **Antimicrobial treatment—lock therapy**

INFECTIVE ENDOCARDITIS

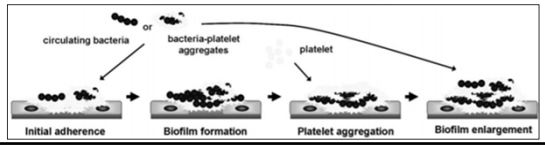
- **Biofilm associated with commensal strep on damaged heart valves**
- **Fibrin-platelet complex embedded with bacteria on heart valve**



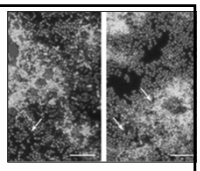
ENDOCARDITIS



- **Platelets essential**
- **Biofilm induced aggregation**
- **Platelets increase resistance**



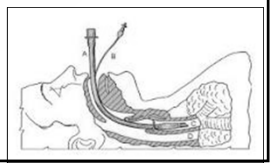
AIRWAY BIOFILMS

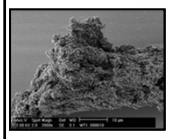


- Cystic fibrosis , diffuse panbronchiolitis and bronchiectasia with *Pseudomonas aeruginosa*
- Acute exacerbations from planktonic bacteria that dispersed from biofilm
- Slow progressive disease that induced by harmful immune reactions

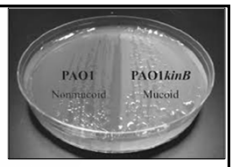
ENDOTRACHEAL TUBE COLONIZATION AND VENTILATOR-ASSOCIATED PNEUMONIA

- Readily accumulate within hours
- Aerosolization releases to cause pneumonia
- Major reservoir—50% of pneumonia caused by biofilm organisms
- Associated with treatment failure
- Oral and enteric organisms
- Under estimated by current cultures



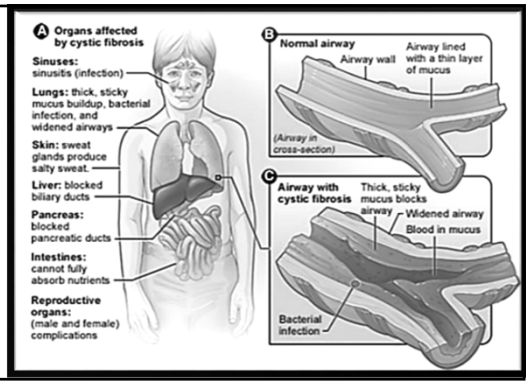


CYSTIC FIBROSIS

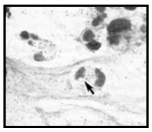


- Dehydrated and thickened airway surface liquid
- Hinders mucociliary clearance
- Colonize and cause an initial acute infection and vigorous inflammatory response
- Thickened ASL severely impairs the immune response
- Chronic lung inflammation

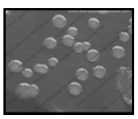
CF



BIOFILMS IN COPD

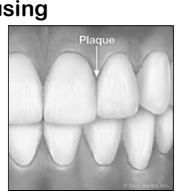


- 24 million in U.S. 3rd cause of death worldwide
- Intermittent exacerbations-50% infections
- Nontypeable *Haemophilus influenzae*

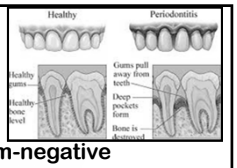


ORAL BIOFILMS (PLAQUE)

- Influenced by: age, dietary sugar, oral hygiene, systemic and immune conditions, hyposalivation
- Sugar crevices, attracts pathogens causing inflammation and gingivitis
- Plague accumulates at the sulcus
- Undisturbed spreads over teeth
- Good oral hygiene removes this plaque



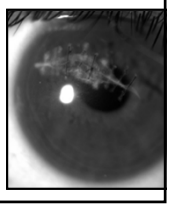
DENTAL BIOFILMS



- If accumulation occurs:
  - Switch from gram-positive to gram-negative bacteria
    - Anaerobic and facultative anaerobic, gram-negative bacilli and spirochetes
  - Pathogens
    - *Porphyromonas gingivalis, Bacteroides forsythia, Aggregatibacter actinomycetemcomitans, Treponema denticola*
  - Causes periodontitis—destroys bone and tissue

BIOFILMS ON CONTACT LENSES

- May lead to microbial keratitis—*Ps. aeruginosa*—*Serratia marcescens, Staph. epidermidis and Staph. aureus*
  - Corneal scarring and vision loss
  - 12-66% contact lens wearers

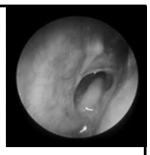


- Acute red eye—34% of continuous wear
- Peripheral ulcer
- Infiltrative keratitis

BIOFILMS ON CONTACT LENSES

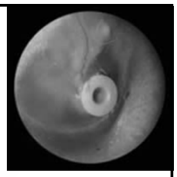
- Influenced by
  - Length of wear
  - Pathogen
  - Deposited proteins
  - Lens material (hydrophobicity, roughness)

OTITIS MEDIA



- 80% of children develop OM before age 3
- Recurrent, nonresponsive or chronic—biofilm
- Mixed pathogen: *Streptococcus pneumoniae* and nontypeable *Haemophilus influenza*
- Biofilm more likely with combination and greater resistance
- *S. pneumoniae* differs by serotype

TYMPANOSTOMY TUBE



- 600,000 placed in children per year
- Tube otorrhea (83%) and occlusion (74%)
- Acute infections: *Streptococcus pneumonia* and *Haemophilus influenza*
- Chronic: *Staphylococcus aureus* and *Pseudomonas aeruginosa*
- Financial and operative burden
- Organoselenium coating lessens *S. aureus* biofilm

URINARY TRACT INFECTIONS

- Cause relapses, reinfection and chronic prostatitis
- 20% of UTIs
- *Escherichia coli* cause ~80%
- Urinary catheters—80% nosocomial—all colonized by day 30
- Treatment with nanoparticles

CHRONIC WOUNDS

- Obesity, diabetes, cardiovascular
- $10.9 billion and precede 85% of amputations
- Wound > 1 month
- Diabetic foot ulcers, pressure or decubitus ulcers, venous leg ulcers, and nonhealing surgical-site infections.

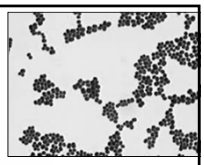
CHRONIC WOUNDS

- Multiple organisms
- *S. aureus, P. aeruginosa*
- *P. aeruginosa* –larger wounds, delay or prevent healing

TREATMENT OF CHRONIC WOUNDS

- Debridement
- Antibiotics and anti-inflammatory drugs
- Moisture imbalance corrected with dressings
- Epithelialization and tissue formation promoted specific therapies, such as growth factors

STAPHYLOCOCCUS



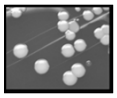
- *S. aureus* and *S. epidermidis*
- Osteomyelitis, endocarditis, medical device implants, and persistence in cystic fibrosis
- 10,000-fold lower # needed to colonize foreign body than to cause skin abscess
- Secreted polysaccharide (slime) required

STAPHYLOCOCCUS AUREUS

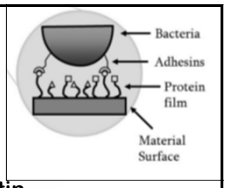
- High morbidity and mortality in endovascular
- Infective endocarditis, osteomyelitis, arthritis
- Sublethal doses of vancomycin can induce biofilms in MRSA
- Foci for metastatic spread and toxin release
- Matrices consist of proteins, DNA, and polysaccharide
- Polysaccharide not essential—protein in highly virulent

STAPHYLOCOCCUS EPIDERMIDIS

- Normal microbiome
- Causes ~ 20% of orthopedic device-related infections
- Increasing up to 50% in late-developing infections
- Prominent in any implanted device infection
- Low level of virulence factors
- Triggers low levels of pro-inflammatory cytokines and high levels of interleukin-10
- May contribute to the sub-acute and persistent nature



S. EPIDERMIDIS BIOFILM



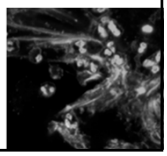
- Protein coating required—fibronectin
- Polysaccharide intercellular adhesion
- Or accumulation associated protein (less robust)
- Form different structures

S. EPIDERMIDIS AS A PATHOGEN

- Preterm neonates
- Immunocompromised
- Indwelling medical devices

STAPHYLOCOCCAL EVASION OF THE HOST IMMUNE SYSTEM

- PMNs can attack biofilms by phagocytosis, release of toxic granule components, and production of NETs
- Extracellular polysaccharide prevents attachment
- agr adhesion molecule kills PMNs
- Extracellular nuclease can degrade NETs

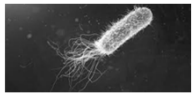


STAPHYLOCOCCUS LUGDUNENSIS

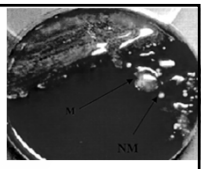
- Most similar to coagulase-positive Staphylococci
- Skin commensal and opportunistic pathogen
- 0.8%–7.8% of infectious endocarditis cases in nondrug users with morality rates 38%–42%
- Infections of medical devices, such as catheters and prosthetic joints
- Significant cause of skin and soft-tissue infections

PSEUDOMONAS AERUGINOSA

- Ventilator-associated pneumonia, cystic fibrosis meningitis, abscess, infections of skin and soft tissues (including diabetic foot), urinary tract, bone and joint, bacteremia, corneal infections, systemic diseases
- Immunosuppressed patients
- MDR and avid biofilm producer
- Catheters (urinary & vascular), ventilator tubes, chronic leg wounds

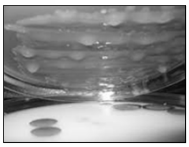


ALGINATE



- Soft loosely adhered polymer that surrounds the cells
- Protects *P. aeruginosa* from harsh environments in CF lungs
- Provides extracellular matrix in biofilms—up regulated
- Virulence factors and motility downregulated

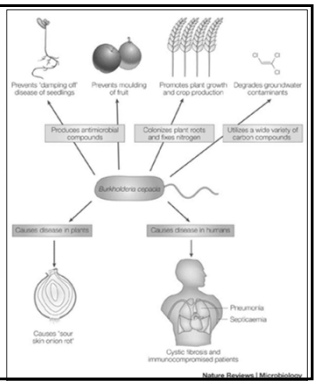
ALGINATE



- Inhibits immune defenses
  - Inhibition of bacterial uptake and killing by macrophages
  - Prevents activation of the complement alternative pathway
  - Reduces opsonophagocytosis
- Structural stability and protection of biofilms
- Necessary for water and nutrient retention

BURKHOLDERIA CENOCEPACIA

- Beneficial OR
- Opportunistic pathogen
- Severe lung infections, necrotizing pneumonia and septicaemia in CF
- 9 species (genomovars)
- *B. cenocepacia* (genomovar III) and *B. multivorans* (genomovar II)

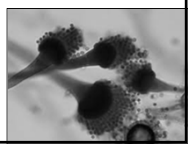


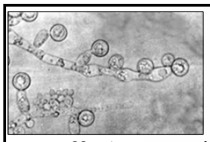
BURKHOLDERIA CENOCEPACIA

- Decline in CF lung function
- May develop into systemic infection--cepacia syndrome
- Major cause of premature death and lung transplant
- Post transplant infections morbidity & mortality
- Antibiotic resistance and numerous virulence factors

ASPERGILLUS FUMIGATUS BIOFILMS

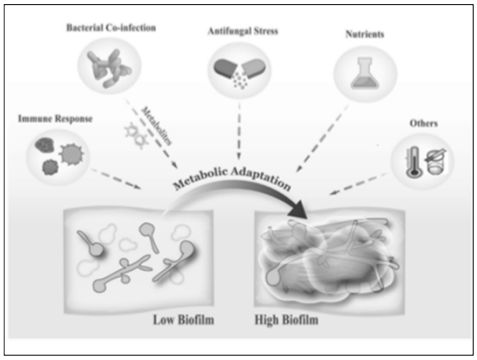
- Newly identified biofilm producer
- Conceals β-glucans from recognition by an innate immune pattern recognition receptor
- Protects hyphae from neutrophil extracellular traps
- Contributes to high treatment failure rate





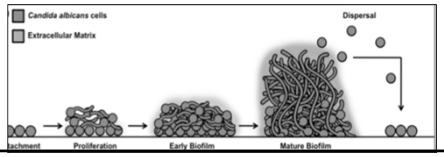
CANDIDA ALBICANS

- Most common human fungal pathogen--ranging from mucosal to systemic infections
- Asymptomatically colonizes mucosal surfaces
- Disruption in the host environment or immune dysfunction, proliferates and invades any site
- Adheres to catheters and indwelling medical implants
- 3rd most commonly isolated bloodstream pathogen in hospitalized patients with a mortality up to 50%

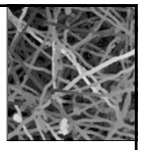


CANDIDA ALBICANS

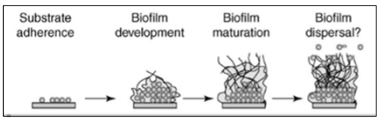
- Majority of infections associated with biofilms
- Indwelling medical devices--high morbidity and mortality
- Significant drug resistance



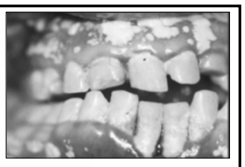
BIOFILM



- Production of hyphae is a hallmark of initiation formation
- Accumulation of extracellular polysaccharide matrix as matures-- -mannan & glucan
- Dispersal of yeast seeds to other organs (differ from planktonic yeast)



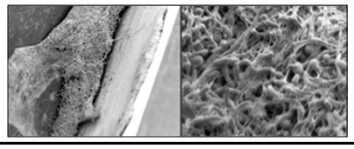
THRUSH



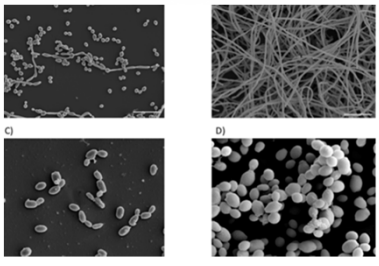
- Pseudomembranous candidiasis
- Most common oral opportunistic infection in HIV+ and other immunocompromised individuals
- Denture stomatitis occurs in up to 70% of denture wearers--chronic

CANDIDA IN VASCULAR CATHETERS

- Most dangerous—20% polymicrobic
- Up to 20,000-fold increase in antifungal MICs
- ↓ growth rate, cell density, modified target, efflux
- Persisters and extracellular matrix

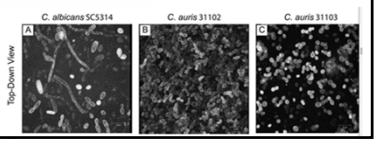


MIXED *CANDIDA* BIOFILMS



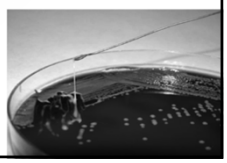
CANDIDA AURIS

- New multi-resistant invasive yeast with high mortality (60%)
- Ability to attach to silicon elastomer catheter significantly less than *C. albicans*
- Did not produce hyphae in biofilms & had much less extracellular matrix
- Half as thick as *C. albicans*



KLEBSIELLA PNEUMONIAE

- Pneumonia, UTI, liver abscess
- Most frequently associated with nosocomial infections in US-indwelling urinary catheters
- ESBL and CRP
- Polysaccharide capsule
- Fibrae important in UTI biofilms

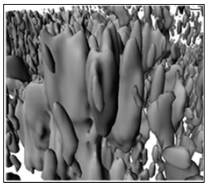


KLEBSIELLA PNEUMONIA BIOFILM IN UTI

- Resistant to long exposure to ampicillin and ciprofloxacin, gentamicin, cefotaxime
- Polysacchride capsule, fimbrae
- Enhanced in mixed esp. with *Ps. aeruginosa, E. coli,P. mirabilis, organella, Enterobacter, C. albicans Streptococcus*

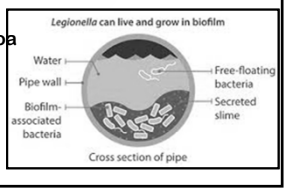
ESCHERICHIA COLI UTI BIOFILMS

- Biofilm in GI tract also—250 serotypes
- From harmless gut commensal to pyelonephritis and sepsis
- Primary urinary biofilm producer
- Wide array of genetic tools, fimbrae and flagella



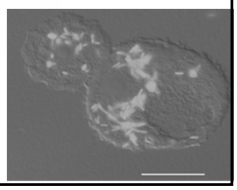
LEGIONELLA PNEUMOPHILA

- Severe respiratory illness with fatality from 5% to 80%
- Aerosols
- Ubiquitous in natural and anthropogenic water systems
- Biofilms essential in water systems
- Usually monospecies or with protozoa
- Enhanced virulence



LEGIONELLA PNEUMOPHILA

- Amount of biofilm directly correlated with the biomass of protozoa
- Replicate inside protozoa
- Adhere well to plastic, not copper
- *Pseudomonas* inhibitory
- *Acanthamoeba castellanii*

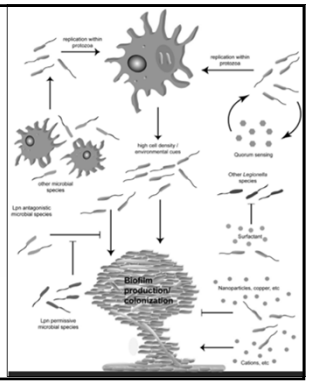


FACTORS THAT INFLUENCE BIOFILMS

- CA, Zn, Ma, Fe AND Mg facilitate attachment
- Lactoferrin can directly kill *L. pneumophila*
- Carbon at 20° and stagnation
- Heat to 55° reduces
- 37–42 °C, monospecies mycelial mat-like and filamentous bacteria
- 25 °C are thinner and made up of rod shaped cells
- Summer in cooling towers

ELIMINATING *L. PNEUMOPHILA*

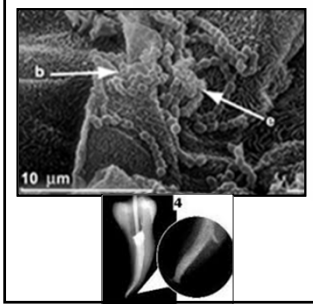
- Extremely resistant to disinfectants and biocides
- Resistant to chloride
- Nanoparticles better



STREPTOCOCCUS PYOGENES

- Pharyngitis, cellulitis, and impetigo to puerperal sepsis, myositis, toxic shock, necrotizing fasciitis
- Post sequelae rheumatic fever and acute glomerulonephritis
- Large amounts of S. pyogenes cells and a lack of neutrophils in necrotizing fasciitis demonstrate biofilms

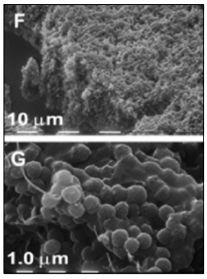
STREPTOCOCCUS PYOGENES



- Biofilm necessary for carriage state in tonsils
- Account for survival with antimicrobial therapy
- Biofilms form on gutta percha points (material used in tooth cavity repair and root canal procedures)

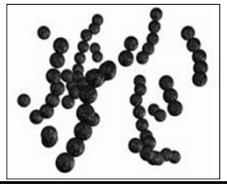
STREPTOCOCCUS PYOGENES

- Ability differs among serotypes (M types)
- M protein necessary to initiate
- Macrolide susceptible strains produce significantly more biofilm than resistant strains
- Penicillin can kill biofilms
- Sub-lethal concentrations of fluoroquinolones can inhibit



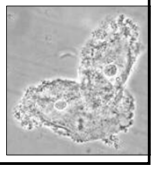
ENTEROCOCCUS

- *E. faecalis* twice the biofilm producer of *E. faecium*
- Catheter-related bloodstream infections
- Endocarditis isolates
- 50% of root canals



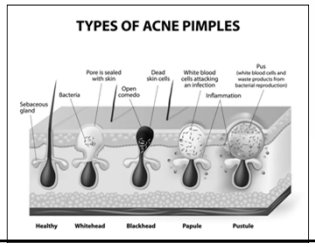
GARDNERELLA VAGINALIS AND ANAEROBES IN BACTERIAL VAGINOSIS BIOFILM

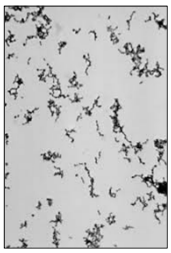
- Most common vaginal disorder in women of reproductive age (60%)
- Causes PID, postoperative infections, preterm birth and susceptibility and spread of HIV
- ↓ lactobacilli & ↑ pathogens, primarily anaerobes
- *Gardenerella vaginalis* first? Most important?
- Different strains?



CUTIBACTERIUM (PROPIONIBACTERIUM) ACNES

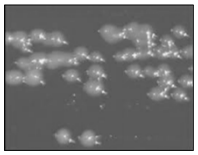
- Skin commensal





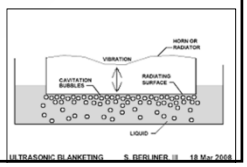
BIOFILM PRODUCER

- Implant-associated infections
- Shoulder prosthetic joint infections
- Cerebrovascular shunt infections
- Fibrosis of breast implants
- Cardiovascular devices



C. ACNES IDENTIFICATION

- Improved diagnostic procedures
  - Sonication
  - Prolonged cultivation time of up to 14 days
  - Improved molecular methods
    - Broad-range 16S rRNA gene PCR



COMPARISON OF BIOFILM INFECTIONS WITH ACUTE AND COMMENSAL

Features of biofilm infections	Necessary condition for biofilm infection	Also found in acute planktonic infection	Also found in colonization/normal flora on skin and mucosal membranes
Aggregates of bacteria embedded in a self-produced polymer matrix	Yes	No	No/Yes
Tolerant of clinically relevant PK/PD* doses of antibiotics, despite the susceptibility of planktonic cells	Yes	No	No/Yes
Tolerant of innate and adaptive immune responses	Yes	No	No/Yes—unknown
Inflammation	Yes	Yes	No
Chronic infections	Yes	No	No
Foreign body-associated infections	No	Initial	No
Located on surfaces	No	Yes	Yes
Localized infection	Yes	Yes	Yes
Focus of spreading or local exacerbation	Yes	Yes	Yes

*PK/PD, pharmacokinetic/pharmacodynamic [adapted from (16)]

SUMMARY OF PATHOGENICITY

- Attachment to a solid surface
- "Division of labor" increases metabolic efficiency
- Evades host defenses
- High density of microorganisms
- Horizontal gene transfer—more virulent strains
- Produces large amount of toxins
- Protects against antimicrobials
- Dispersion transmits organisms to other body sites

SURVEY MONKEY

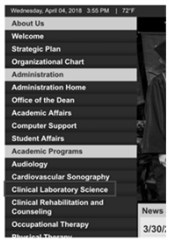
PROGRAM EVALUATIONS

NO SCANTRON SHEETS

CELL PHONE LOGON - GO TO WWW.LSUHSC.EDU

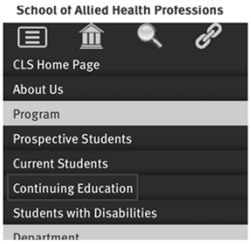
- Click on LSU Health New Orleans and then on the buildin

CLICK ON CLINICAL LABORATORY SCIENCE

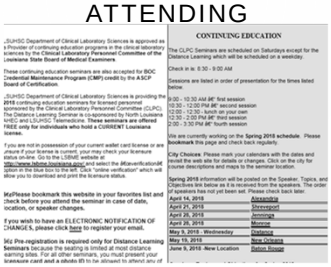


CLICK ON THE ICON BELOW

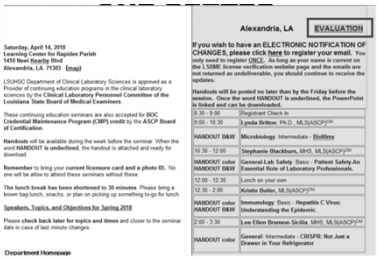
CLICK ON CONTINUING EDUCATION



CLICK ON THE CITY YOUR ARE ATTENDING



WOULD IT BE BETTER HERE OR AT THE BOTTOM? I'M KIND OF LIKING THIS



EVALUATION ON LAPTOP C

- **LSUH home page, click on Allied Health Professions**
- **Click on Clinical Laboratory Science**

EVALUATION ON LAPTOP OR DESKTOP

- **Click on Continuing Education**
- **click on city of choice**

INSTRUCTIONS

- QUESTION 1 - LICENSE NUMBER
- QUESTIONS 2 AND 3 - SPEAKER 1
- SAME QUESTIONS AS SCANTRON SHEETS
- CLICK NEXT TO SAVE
- QUESTIONS 4 AND 5 - SPEAKER 2
- QUESTIONS 6 AND 7 – SPEAKER 3
- QUESTIONS 8 AND 9 – SPEAKER 4
- QUESTION 10 – RECOMMENDATIONS
- QUESTION 11 – GENERAL COMMENTS/FUTURE PROGRAMS
- CHANGES CAN BE MADE TO ANY PAGE UNTIL YOU CLICK DONE AFTER QUESTION 11.