Pseudomonas and Nonfermenters

General Overview

- **Opportunistic** Pathogens of Plants, Animals, and Humans
- **Many Taxonomic Changes** in Last Decade
- Clinically Important **Aerobic Gram-Negative Bacilli** Include:
  - **Aerobic nonfermenters**: 10-15% of clinical isolates
    - ✔ ***Pseudomonas aeruginosa; Burkholderia cepacia; Stenotrophomonas maltophilia; Acinetobacter baumannii; Moraxella catarrhalis***: Account for >75% of all clinical isolates of aerobic nonfermenters
  - Facultative anaerobes and microaerophiles: 70-80% of clinical isolates
  - *Haemophilus* & related organisms: 10-15% of clinical isolates
  - Unusual bacilli: <1% of clinical isolates
- Pseudomonads Classified into Five rRNA Groups

General Characteristics of Nonfermenters

- **Oxidative gram-negative bacilli**, including ***Pseudomonas*** spp., **produce acid from glucose or other carbohydrates** **only in the presence of oxygen** (**nonfermenters**).
  - **NOTE:** *Enterobacteriaceae*, *Aeromonas* and *Vibrio* are fermentative and can utilize carbohydrates in the absence of oxygen.
- ***Pseudomonas aeruginosa*** **oxidizes but does not ferment glucose**. *Alcaligenes faecalis* neither ferments nor oxidizes glucose (see Lab Manual).

Clinically Important Nonfermentative Gram-Negative Bacilli

Achromobacter
Acinetobacter
Agrobacterium
Alcaligenes — Lab only
Balneatrix
Bordetella — Later
Brevundimonas
Burkholderia
Chryseobacterium
Flavobacterium
Methylobacterium
Moraxella
Ochrobactrum
Oligella
Pseudomonas
Psychrobacter
Ralstonia
Roseomonas
Shewanella
Sphingomonas
Stenotrophomonas

Pseudomonas aeruginosa

(Family Pseudomonadaceae)

Characteristics of Pseudomonas aeruginosa

- **Motile** (by single or multiple polar flagella) gram-negative rods
- Obligate (strict) **aerobes** (most strains)
- **Oxidase** (usually) and **catalase positive**
- Nonfermentative chemoheterotrophic respiratory metabolism
- **Minimal nutritional reqts.; Many organic compounds used** as C and N sources, but only a few carbohydrates by oxidative metabolism
  - Glucose used oxidatively
  - **Lactose negative** on MacConkey's agar
- Some strains produce **diffusible pigments**:
  - Pyocyanin (blue); fluorescein (yellow); pyorubin (red)
- *P. aeruginosa* produces **characteristic grape-like odor and blue-green pus & colonies**
- **Broad antibiotic resistance**

Pseudomonas aeruginosa Infections

Survive where most organisms cannot; e.g., “oil-eating” bacteria are *Pseudomonas.*

Physiology and Structure

Small gram-negative bacilli.

Strict aerobe.

Nonfermenter.

Simple nutritional requirements.

Mucoid exopolysaccharide capsule. **(Slime layer)**

Virulence

Refer to Table 32–1 for complete listing.

Epidemiology

Ubiquitous in moist environmental sites in the hospital (e.g., flowers, sinks, toilets, respiratory and dialysis equipment) as well as in nature.

No seasonal incidence of disease.

Can transiently colonize the respiratory and gastrointestinal tracts of hospitalized patients, particularly those treated with broad-spectrum antibiotics, exposed to respiratory therapy equipment, or hospitalized for extended periods.

Pseudomonas aeruginosa Infections (cont.)

Characteristic **grape-like odor**. Bluish-green color clinically and in the lab due to presence of two pigments: **pyocyanin & fluorescein.**

Diseases

Pulmonary infections (common in patients with cystic fibrosis).

Burn wound infections and other skin and soft tissue infections (can be life-threatening).

Urinary tract infections (primarily in catheterized patients).

External otitis (varying from mild "swimmer's ear" to malignant otitis externa).

Eye infections (commonly associated with contaminated contact lens cleaning fluids).

Diagnosis

Readily grow on common laboratory media. *P. aeruginosa* is identified by colonial characteristics (e.g., hemolytic, green pigment, grapelike odor) and simple biochemical tests (e.g., positive oxidase reaction).

Treatment, Prevention, and Control

Combined use of effective antibiotics (e.g., aminoglycoside and β-lactam antibiotics) frequently required. Monotherapy is generally ineffective and can select for resistant strains.

Hyperimmune globulin and granulocyte transfusions may be beneficial in selected infections in immunocompromised patients.

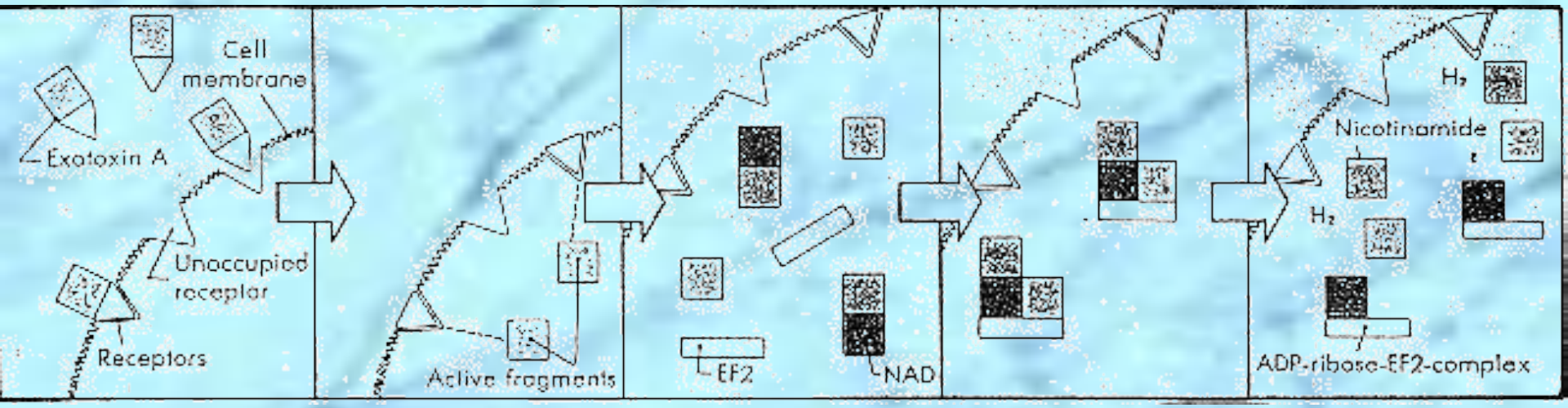
Hospital infection control efforts should concentrate on preventing contamination of sterile medical equipment and nosocomial infections.

Unnecessary use of broad-spectrum antibiotics can select for resistant organisms such as *P. aeruginosa*.

Virulence Factors Associated with Pseudomonas aeruginosa

Virulence Factors	Biologic Effects
Structural Components	
Capsule	Mucoid exopolysaccharide; adhesin; inhibits antibiotic (e.g., aminoglycoside) killing; suppresses neutrophil and lymphocyte activity
Pili	Adhesin
Lipopolysaccharide (LPS)	Endotoxin activity
Pyocyanin	Impairs ciliary function; stimulates inflammatory response; mediates tissue damage through production of toxic oxygen radicals (i.e., hydrogen peroxide, superoxide, hydroxyl radicals)
Toxins and Enzymes	
Exotoxin A	Inhibitor of protein synthesis; produces tissue damage (e.g., skin, cornea); immunosuppressive
Exotoxin S	Inhibits protein synthesis; immunosuppressive
Cytotoxin (leukocidin)	Cytotoxic for eukaryotic membranes (e.g., disrupts leukocyte function, produces pulmonary microvascular injury)
Elastase	Destruction of elastin-containing tissues (e.g., blood vessels, lung tissue, skin), collagen, immunoglobulins, and complement factors
Alkaline protease	Tissue destruction; inactivation of interferon and tumor necrosis factor-α
Phospholipase C	Heat-labile hemolysin; mediates tissue damage; stimulates inflammatory response
Rhamnolipid	Heat-stable hemolysin; disrupts lecithin-containing tissues; inhibits pulmonary ciliary activity
Antibiotic resistance	Complicates antimicrobial therapy

Mechanism of Action of Exotoxin A



Mechanisms of Antibiotic Resistance in Pseudomonas aeruginosa

Antibiotic	Resistance Mechanisms
β-lactams	β-lactamase hydrolysis, decreased permeability, altered binding proteins
Aminoglycosides	Enzymatic hydrolysis by acetylation, adenylation, or phosphorylation; decreased permeability; altered ribosomal target
Chloramphenicol	Enzymatic hydrolysis by acetyltransferase; decreased permeability
Fluoroquinolones	Altered target (DNA gyrase); decreased permeability

Burkholderia cepacia

Diseases Associated with Burkholderia spp.

Species	Diseases
B. cepacia	Respiratory tract infections, particularly in patients with cystic fibrosis; urinary tract infections; septic arthritis; peritonitis; septicemia; opportunistic infections
B. pseudomallei	Asymptomatic colonization; cutaneous infection with regional lymphadenitis, fever, and malaise; pulmonary disease ranging from bronchitis to necrotizing pneumonia
B. gladioli	Colonization of respiratory tracts of patients with cystic fibrosis
B. mallei	Glanders in livestock

Stenotrophomonas maltophilia

Stenotrophomonas maltophilia

GENERAL OVERVIEW

- **Formerly** *Pseudomonas maltophilia* and then *Xanthomonas maltophilia*
- **Nosocomial** infections
- Normal flora can infect wounds, urinary tract, & blood

CLINICAL SYNDROMES

Opportunistic Nosocomial Infections

- Bacteremia
- Pneumonia
- Meningitis
- Wound Infections
- Urinary Tract

Stenotrophomonas maltophilia (cont.)

EPIDEMIOLOGY

- Hospital Epidemics from Contaminated Moist Reservoirs:
  - Disinfectant solutions
  - Respiratory equipment
  - Ice machines
  - Flower vases
- Risk Factors
  - Hospitalization
  - Impaired host defense mechanisms (e.g., highly immunocompromised)
  - Long-term broad-spectrum antibiotics (e.g., bone marrow transplant patients)

Stenotrophomonas maltophilia (cont.)

TREATMENT, PREVENTION, AND CONTROL

- Resistance to Multiple Antibiotics (e.g., Beta-lactams; Aminoglycosides)
- Susceptible to:
  - Trimethoprim-sulfamethoxazole
  - Chloramphenicol; Tetracycline
  - Ceftazidime

Acinetobacter baumanii

Acinetobacter baumanii

CLINICAL SYNDROMES

Opportunistic Infections

- Respiratory tract
- Urinary tract
- Wounds
- Septicemia

EPIDEMIOLOGY

- Niches Include:
  - Natural environments
  - Moist surfaces in hospitals (e.g., respiratory therapy equipment)
  - Dry surfaces (e.g., human skin); rare for gram-negative bacilli
  - Occasionally normal flora in oropharynx

TREATMENT, PREVENTION & CONTROL

- Antibiotic Resistance Common
- Empirical Treatment for Acute Infections: β-lactam + Aminoglycoside
- Specific Therapy According to Antibiotic Susceptibility

Moraxella catarrhalis

Moraxella catarrhalis

GENERAL OVERVIEW

- Formerly classified as *Neisseria* & more recently *Branhamella*

CLINICAL SYNDROMES

- In Elderly Patients with Chronic Pulmonary Disease
  - Bronchitis
  - Bronchopneumonia
- In Previously Healthy People
  - Sinusitis
  - Otitis

TREATMENT, PREVENTION, AND CONTROL

- Most strains produce β-lactamase; Penicillin Resistant

REVIEW

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Clinically Important Nonfermentative Gram-Negative Bacilli

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Agrobacterium	*Flavobacterium*	*Ralstonia*
Alcaligenes (Lab only)	*Methylobacterium*	*Roseomonas*
Balneatrix	*Moraxella*	*Shewanella*
Bordetella (Later)	*Ochrobactrum*	*Sphingomonas*
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Review of Pseudomonas aeruginosa

(Family Pseudomonadaceae)

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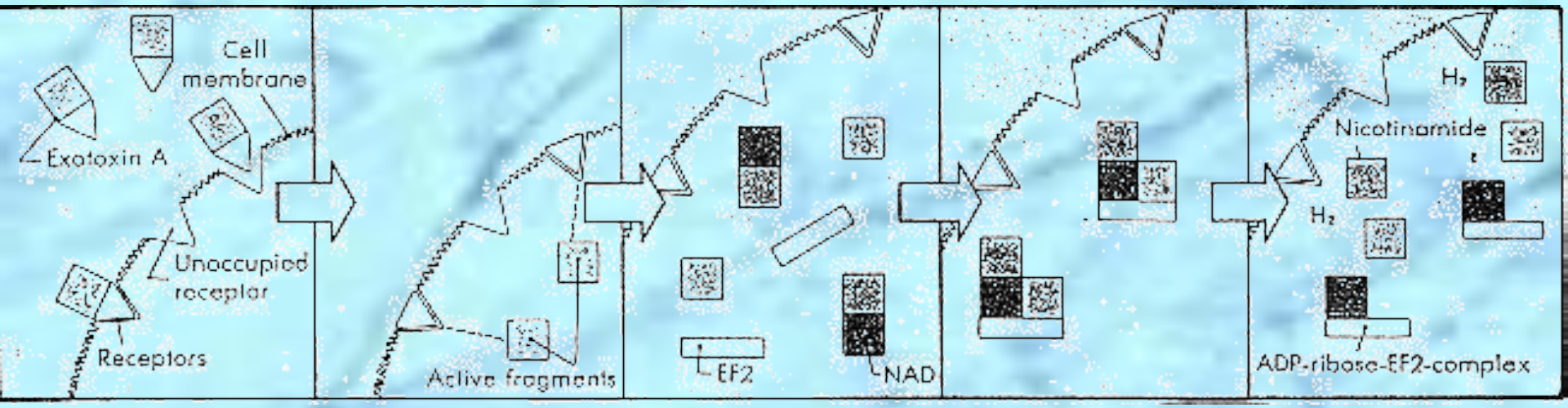

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Stenotrophomonas maltophilia (cont.)

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Acinetobacter baumanii

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