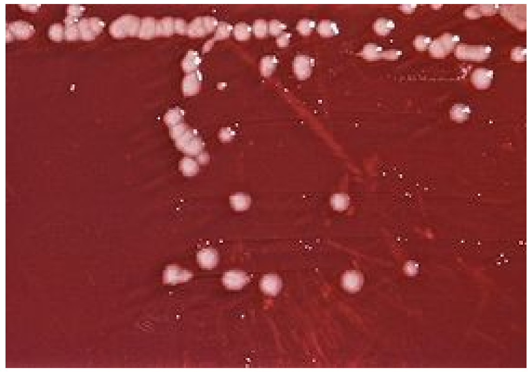
Pseudomonas



P. aeruginosa colonies on an agar plate

Classification

Kingdom:	Bacteria
Phylum:	Proteobacteria
Class:	Gamma Proteobacteria
Order:	Pseudomonadales
Family:	Pseudomonadaceae
Family:	Pseudomonadaceae

Type species

Pseudomonas aeruginosa

Species

P. aerugino
P. chlororaphis
P. fluorescens
P. pertucinogena
P. putida
P. stutzeri

History

Pseudomonad literally means 'false unit', being derived from the Greek *pseudo* ('false') and *monas* ('a single unit'). The term "monad" was used in the early history of microbiology to denote single-celled organisms. The generic name *Pseudomonas* created for these organisms was defined in rather vague terms in 1894 as a genus of Gram-negative, rod-shaped and polar-flagella bacteria. Soon afterwards, Pseudomonads were isolated from many natural niches and a large number of species names was originally assigned to the genus. New methodology and the inclusion of approaches based on the studies of conservative macromolecules have reclassified many strains. *Pseudomonas aeruginosa* is increasingly recognized as an emerging opportunistic pathogens of clinical relevance.

Characteristics

Members of the genus display the following defining characteristics

- Rod shaped
- Gram negative
- One or more polar flagella, providing motility
- Aerobicnon spore former
- Positive catlasetest

Other characteristics which tend to be associated with *Pseudomonas* species (with some exceptions) include secretion of pyoverdin (fluorescein)), a fluorescent yellow-green siderophore under iron-limiting conditions. Certain *Pseudomonas* species may also produce additional types of siderophore, such as pyocyanin by *Pseudomonas aeruginosa* and thioquinolobactin by *Pseudomonas aeruginosa*. *Pseudomonas* species also typically give a positive result to the oxidase test, the absence of gas formation from glucose, glucose is oxidised in oxidation/fermentation test using Hugh and Leifson O/F test, beta haemolytic (on blood agar), indol negative, methyl red negative, Voges Proskauer test negative, citrate positive.

Biofilm formation

All species and strains of *Pseudomonas* are Gram negative rods, and have historically been classified as strict aerobes. A significant number can produce exopolysaccharides that are known a slime layers. Secretion of exopolysaccharide makes it difficult for Pseudomonads to be phagocytosed by mammalian white blood cells.Slime production also contributes to surface-colonising bioflims which are difficult to remove from food preparation surfaces. Growth of Pseudomonads on spoiling foods can generate a "fruity" odor.

Antibiotic resistance

Being Gram-negative bacteria, most *Pseudomonas spp.* are naturally resistant to penicillin and the majority of related beta-lactum antibiotics, but a number are sensitive to pipercillin, ciprofloxacin.

This ability to thrive in harsh conditions is a result of their hardy cell walll that contains porins.

Pathogenicity

Animal pathogens

Infectious species include *P. aeruginosa*, P. oryzihabitans and P. plecoglossicida. *P. aeruginosa* flourishes in hospital environments, and is a particular problem in this environment since it is the second most common infection in hospitalized patients(nosocomial infections). This pathogenesis may in part be due to the proteins secreted by *P. aeruginosa*. The bacterium possesses a wide range of secretion machineries and exports numerous protein substrates considered to be important in the pathogenesis of clinical strains.

Food spoilage agents

As a result of their metabolic diversity, ability to grow at low temperatures and ubiquitous nature, many *Pseudomonas* can cause food spoilage. Notable examples include dairy spoilage by *P. fragi* mustiness in eggs caused by *P. taetrolens* and P. mudicolens and P. lundensis, which causes spoilage of milk,cheese, meat and fish.

Species previously classified in the genus

Recently, 16S rRNA sequence analysis redefined the taxonomy of many bacterial species previously classified as being in the *Pseudomonas* genus. Species which moved from the *Pseudomonas* genus are listed below; clicking on a species will show its new classification. Note that the term 'Pseudomonad' does not apply strictly to just the *Pseudomonas* genus, and can be used to also include previous members such as the genera Buckholderia and Ralstonia.

Pseudomonas aeruginosa

Gram stain of *Pseudomonas aeruginosa* cells

***Pseudomonas aeruginosa* is member of the Gamma Proteobacteria class of Bacteria.**

Characteristics

Pseudomonas aeruginosa is member of the Gamma Proteobacteria class of Bacteria.It is a Gram-negative rod measuring 0.5 to 0.8 µm by 1.5 to 3.0 µm. Almost all strains are motile by means of a single polar flagellum.

The bacterium is ubiquitous in soil and water, and on surfaces in contact with soil or water. Its metabolism is respiratory and never fermentative, but it will grow in the absence of O_2 *if* NO_3 *is available as a respiratory electron acceptor.*

• Pseudomonas aeruginosa has very simple nutritional requirements. It is often observed "growing in distilled water", which is evidence of its minimal nutritional needs. In the laboratory, the simplest medium for growth of Pseudomonas aeruginosa consists of acetate as a source of carbon and ammonium sulfate as a source of nitrogen.

• Its optimum temperature for growth is 37 degrees, and it is able to grow at temperatures as high as 42 degrees.

• It is tolerant to a wide variety of physical conditions, including temperature. It is resistant to high concentrations of salts and dyes, weak antiseptics, and many commonly used antibiotics.

• Pseudomonas aeruginosa has a predilection for growth in moist environments, which is probably a reflection of its natural existence in soil and water.

P. aeruginosa isolates may produce three colony types. Natural isolates from soil or water typically produce a small, rough colony. Clinical samples, in general, yield one or another of two smooth colony types. One type has a fried-egg appearance which is large, smooth, with flat edges and an elevated appearance. Another type, frequently obtained from respiratory and urinary tract secretions, has a mucoid appearance, which is attributed to the production of alginate slime. The smooth and mucoid colonies are presumed to play a role in colonization and virulence.

Pseudomonas aeruginosa colonies on agar

P. aeruginosa strains produce two types of soluble pigments, the fluorescent pigment pyoverdin and the blue pigment pyocyanin. The latter is produced abundantly in media of low-iron content and functions in iron metabolism in the bacterium. Pyocyanin (from "pyocyaneus") refers to "blue pus", which is a characteristic of suppurative infections caused by Pseudomonas aeruginosa.

Resistance to Antibiotics

Pseudomonas aeruginosa is notorious for its resistance to antibiotics and is, therefore, a particularly dangerous and dreaded pathogen. The bacterium is naturally resistant to many antibiotics due to the permeabiliity barrier afforded by its Gram-negative outer membrane. Only a few antibiotics are effective against *Pseudomonas aeruginosa*, including fluoroquinolones, gentamicin and imipenem, and even these antibiotics are not effective against all strains.

Diagnosis

Diagnosis of *P.aeruginosa* infection depends upon isolation and laboratory identification of the bacterium. It grows well on most laboratory media and commonly is isolated on blood agar or eosin-methylthionine blue agar. It is identified on the basis of its Gram morphology, inability to ferment lactose, a positive oxidase reaction, its fruity odor, and its ability to grow at 42°C. Fluorescence under ultraviolet light is helpful in early identification of *P.s aeruginosa* colonies. Fluorescence is also used to suggest the presence of *P. aeruginosa* in wounds.

Pathogenesis

For an opportunistic pathogen such as *Pseudomonas aeruginosa*, the disease process begins with some alteration or circumvention of normal host defenses. The pathogenesis of *Pseudomonas*s infections is multifactorial, as suggested by the number and wide array of **virulence** determinants possessed by the bacterium. Multiple and diverse determinants of virulence are expected in the wide range of diseases caused, which include septicemia, urinary tract infections, pneumonia, chronic lung infections, endocarditis, dermatitis, and osteochondritis.

Most *Pseudomonas* infections are both invasive and toxinogenic. The ultimate *Pseudomonas* infection may be seen as composed of three distinct stages: (1) bacterial attachment and colonization; (2) local invasion; (3) disseminated systemic disease. However, the disease process may stop at any stage. Particular bacterial determinants of virulence mediate each of these stages and are ultimately responsible for the characteristic syndromes that accompany the disease.

Colonization

Colonization of the respiratory tract by *Pseudomonas* requires pili adherence and may be aided by production of a protease enzyme that degrades fibronectin in order to expose the underlying pilus receptors on the epithelial cell surface.

Invasion

The ability of *Pseudomonas aeruginosa* to invade tissues depends upon production of extracellular enzymes and toxins that break down physical barriers and damage host cells, as well as resistance to phagocytosis and the host immune defenses. As mentioned above, the bacterial capsule or slime layer effectively protects cells from opsonization by antibodies, complement deposition, and phagocyte engulfment.

Two extracellular proteases have been associated with virulence that exert their activity at the invasive stage: elastase and alkaline protease.

Virulence Determinants of Pathogenic *Pseudomonas aeruginosa*

Adhesins
pili (N-methyl-phenylalanine pili)
polysaccharide capsule (glycocalyx)
alginate slime (biofilm)

Invasins
elastase
alkaline protease
hemolysins (phospholipase and lecithinase)
cytotoxin (leukocidin)
siderophores and siderophore uptake systems
pyocyanin diffusible pigment

Motility/chemotaxis
flagella
Retractile pili

Toxins
Exoenzyme S
Exotoxin A
Lipopolysaccharide

Antiphagocytic surface properties
capsules, slime layers
LPS
Biofilm construction

Defense against serum bactericidal reaction
slime layers, capsules, biofilm
LPS
protease enzymes

Defense against immune responses
capsules, slime layers, biofilm
protease enzymes

Genetic attributes
genetic exchange by transduction and conjugation
inherent (natural) drug resistance
R factors and drug resistance plasmids

Ecological criteria
adaptability to minimal nutritional requirements
metabolic diversity
widespread occurrence in a variety of habitats

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