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Proteus

.***Protean (disambiguation).***

In Greek mythology, **Proteus** (/ˈproʊtiəs, -tjuːs/;Greek: Πρωτεύς) is an early sea-god or god of rivers and oceanic bodies of water, one of several deities whom Homer calls the "Old Man of the Sea".[2] Some who ascribe to him a specific domain call him the god of "elusive sea change", which suggests the constantly changing nature of the sea or the liquid quality of water in general. He can foretell the future, but, in a mytheme familiar to several cultures, will change his shape to avoid having to; he will answer only to someone who is capable of capturing him. From this feature of Proteus comes the adjective **protean**, with the general meaning of "versatile", "mutable", "capable of assuming many forms". "Protean" has positive connotations of flexibility, versatility and adaptability.

Proteus is a genus of Gram-negative Proteobacteria. *Proteus* bacilli are widely distributed in nature as saprophytes, being found in decomposing animal matter, sewage, manure soil, and human and animal feces. They are opportunistic pathogens, commonly responsible for urinary and septic infections, often nosocomial.

Clinical significance

Three species—*P. vulgaris*, *P. mirabilis*, and *P. penneri*—are opportunistic human pathogens. *Proteus* includes pathogens responsible for many human urinary tract infections. *P. mirabilis* causes wound and urinary tract infections. Most strains of *P. mirabilis* are sensitive to ampicillin and cephalosporins. *P. vulgaris* is not sensitive to these antibiotics. However, this organism is isolated less often in the laboratory and usually only targets immunosuppressed individuals. *P. vulgaris* occurs naturally in the intestines of humans and a wide variety of animals, and in manure, soil, and polluted waters. *P. mirabilis*, once attached to the urinary tract, infects the kidney more commonly than *E. coli*. *P. mirabilis* is often found as a free-living organism in soil and water.

About 10–15% of kidney stones are struvite stones, caused by alkalinization of the urine by the action of the urease enzyme (which splits urea into ammonia and carbon dioxide) of *Proteus* (and other) bacterial species.

Identification

Proteus species do not usually ferment lactose, but have shown to be capable lactose fermenters depending on the species in a triple sugar iron (TSI) test. Since it belongs to the family Enterobacteriaceae, general characters are applied on this genus. It is oxidase-negative but catalase- and nitrate-positive. Specific tests include positive urease (which is the fundamental test to differentiate *Proteus*from *Salmonella*) and phenylalanine deaminase tests.

On the species level, indole is considered reliable, as it is positive for *P. vulgaris*, but negative for *P. mirabilis*. Most strains produce a powerful urease enzyme, which rapidly hydrolyzes urea to ammonia and carbon monoxide; exceptions are some Providencia strains. Species can be motile, and have characteristic "swarming" patterns.[3][4] Underlying these behaviors are the somatic O and flagellar H antigens, so named based on Kauffman–White classification. This system is based on historic observations of Edmund Weil (1879–1922) and Arthur Felix (1887–1956) of a thin surface film produced by agar-grown flagellated ***Proteus*** strains, a film that resembled the mist produced by breath on a glass. Flagellated (swarming, motile) variants were therefore designated H forms (German *Hauch*, for film, literally breath or mist); nonflagellated (nonswarming, nonmotile) variants growing as isolated colonies and lacking the surface film were designated as O forms (German *ohne Hauch*, without film)

Proteus mirabilis

Proteus mirabilis appears as Gram-negative rods after Gram staining under bright-field microscopy with 1000 times magnification.

Proteus mirabilis is a Gram-negative, facultatively anaerobic, rod-shaped bacterium. It shows swarming motility and urease activity. *P. mirabilis* causes 90% of all *Proteus* infections in humans. It is widely distributed in soil and water.

Diagnosis

An alkaline urine sample is a possible sign of *P. mirabilis*. It can be diagnosed in the lab due to characteristic swarming motility, and inability to metabolize lactose (on a MacConkey agar plate, for example). Also *P. mirabilis* produces a very distinct fishy odour.

Disease

This rod-shaped bacterium has the ability to produce high levels of urease, which hydrolyzes urea to ammonia (NH_3), so makes the urine more alkaline. If left untreated, the increased alkalinity can lead to the formation of crystals of struvite, calcium carbonate, and/orapatite. The

bacteria can be found throughout the stones, and these bacteria lurking in the kidney stones can reinitiate infection after antibiotic treatment. Once the stones develop, over time they may grow large enough to cause obstruction and renal failure. *Proteus*species can also cause wound infections, septicemia, and pneumonia, mostly in hospitalized patients.[2]

Treatment

P. mirabilis is generally susceptible to most antibiotics apart from tetracycline, but 10–20% of *P. mirabilis* strains are also resistant to first-generation cephalosporins and ampicillins.

Characteristics

P. mirabilis can use urea. It can produce hydrogen sulfide gas, and forms clear films on growth media. It is motile, possessing peritrichousflagella, and is known for its swarming ability. It is commonly found in the intestinal tracts of humans. *P. mirabilis* is not pathogenic inguinea pigs or chickens. Noteworthy is the ability of this species to inhibit growth of unrelated strains, resulting in a macroscopically visible line of reduced bacterial growth where two swarming strains intersect. This line is named the Dienes line after its discoverer Louis Dienes.

The micro-organism tests:

- Indole-positive and nitrate reductase-positive (no gas bubbles produced)
- Methyl red-positive and Voges-Proskauer negative (Can be both MR- and V-P-positive)
- Catalase positive and cytochrome oxidase-negative
- Phenylalanine deaminase-positive
- Tryptophan test-negative
- Urea test- positive
- Casein test-negative
- Starch test- negative
- Hydrogen sulfide test-positive
- Citrate agar test-negative
- Ornithine decarboxylase-positive
- Lysine decarboxylase-negative

Proteus vulgaris

Proteus vulgaris is a rod-shaped, nitrate-reducing, indole+ and catalase-positive, hydrogen sulfide-producing, Gram-negative bacteriumthat inhabits the intestinal tracts of humans and animals. It can be found in soil, water, and fecal matter. It is grouped with theEnterobacteriaceae and

is an opportunistic pathogen of humans. It is known to cause urinary tract infections and wound infections. (like an ax wound)

The term Proteus signifies changeability of form, as personified in the Homeric poems in Proteus, "the old man of the sea", who tends the sealflocks of Poseidon and has the gift of endless transformation. The first use of the term “Proteus” in bacteriological nomenclature was made by Hauser (1885), who described under this term three types of organisms which he isolated from putrefied meat. One of the three species Hauser identified was *Proteus vulgaris*, so this organism has a long history in microbiology.

Over the past two decades, the genus *Proteus*, and in particular *P. vulgaris*, has undergone a number of major taxonomic revisions. In 1982, *P. vulgaris* was separated into three biogroups on the basis of indole production. Biogroup one was indole negative and represented a new species, *P. penneri*, while biogroups two and three remained together as *P. vulgaris*.

Lab identification

According to laboratory fermentation tests, *P. vulgaris* ferments glucose and amygdalin, but does not ferment mannitol or lactose. *P. vulgaris* also tests positive for the methyl red (mixed acid fermentation) test and is also an extremely motile organism.

When *P. vulgaris* is tested using the API 20E identification system[1] it produces positive results for sulfur reduction, urease production, tryptophan deaminase production, indole production, sometimes positive gelatinase activity, and saccharose fermentation, and negative results for the remainder of the tests on the testing strip.

It is referenced in the Analytical Profile Index using the nine-digit code: 047602157

The optimal growing conditions of this organism is in a facultative anaerobic environment with an average temperature of about 40°C.

The Becton/Dickinson BBL Enterotube II system for identification of members of the family Enterobacteriaceae inoculated with *P. vulgaris* may yield the following results:

- Positive for glucose fermentation (with gas production)
- Negative for lysine and ornithine
- Positive for hydrogen sulfide production and indole production
- Negative for adonitol and lactose
- Negative for arabinose, sorbitol and dulcitol

- Positive for the phenylalanine test and the Harnstoff urea test

P. vulgaris can test positive or negative for citrate. All combine for a "Biocode ID of 31407" for use in the Interpretation Guide/Computer Coding and Identification System. *P. vulgaris* can also test urease negative in solid media (such as in Enterotube), but will be urease positive in liquid media. The CCIS code will still identify it with a negative urease test.

Proteus infections

Etiology and epidemiologyNosocomial infections

- *P. mirabilis* causes 90% of *Proteus* infections.
- *P. vulgaris* and *P. penneri* are easily isolated from individuals in long-term care facilities and hospitals and from patients with underlying diseases or compromised immune systems.
- Patients with recurrent infections, those with structural abnormalities of the urinary tract, those who have had urethral instrumentation, and those whose infections were acquired in the hospital have an increased frequency of infection caused by *Proteus* and other organisms (e.g., *Klebsiella*, *Enterobacter*, *Pseudomonas*, enterococci, and staphylococci)

Clinical expression

Enterobacteriaceae (of which *Proteus* is a member) and *Pseudomonas* species are the micro-organisms most commonly responsible for Gram-negative bacteremia and sepsis.

The presence of the sepsis syndrome associated with a urinary tract infection (UTI) should raise the possibility of urinary tract obstruction. This is especially true of patients who reside in long-term care facilities, who have long-term indwelling urethral catheters, or who have a known history of urethral anatomic abnormalities.

UTI obstruction

Urease production leads to precipitation of organic and inorganic compounds, which leads to struvite stone formation. Struvite stones are composed of a combination of magnesium ammonium phosphate (struvite) and calcium carbonate-apatite. Struvite stone formation can be sustained only when ammonia production is increased and the urine pH is elevated to decrease the solubility of phosphate. Both of these requirements can occur only when urine is infected with a urease-producing organism such as *Proteus*. Urease metabolizes urea into ammonia and carbon dioxide: urea 2 NH_3 + CO_2. The

ammonia/ammonium buffer pair has a pK of 9.0, resulting in the combination of highly alkaline, ammonia-rich urine.

Symptoms attributable to struvite stones are uncommon. More often, women present with UTI, flank pain, or hematuria, and are found to have a persistently alkaline urine pH (>7.0).

Treatments

Known antibiotics to which *P. vulgaris* is sensitive:

Ciprofloxacin
Ceftazidime
Netilmicin
Sublactamorcefoperazone
Meropenem
Piperacillin/tazobactam
Unasyn

Antibiotics should be introduced in much higher doses than "normal" when *P. vulgaris* has infected the sinus or respiratory tissues; for example, ciprofloxacin should be introduced at a level of at least 2000 mg per day orally in such a situation, rather than the "standard" 1000 mg per day.

Swarming motility

Swarming motility is a rapid (2–10 μm/s) and coordinated translocation of a bacterial population across solid or semi-solid surfaces. This type of motility is an example of an emerging concept in microbiology : bacterial multicellularity. Swarming motility was first reported by Jorgen Henrichsenand has been mostly studied in genus *Serratia*, *Salmonella*, *Aeromonas* *Bacillus*, *YersiniaPseudomonas*, *Proteus*, *Vibrio* and *Escherichia*.

This multicellular behavior has been mostly observed in controlled laboratory conditions and relies on two critical elements: 1) the nutrient composition and 2) viscosity of culture medium (i.e. % agar).[4] One particular feature of this type of motility is the formation of dendritic fractal-like patterns formed by migrating swarms moving away from an initial location. Although the majority of species can produce tendrils when swarming, some species like *Proteus mirabilis* do form concentric circles motif instead of dendritic patterns.

Biosurfactant, quorum sensing and swarming

In some species, swarming motility requires the self-production of biosurfactant to occur. Biosurfactant synthesis is usually under the

control of an intercellular communication system called quorum sensing. Biosurfactant molecules are thought to act by lowering surface tension, thus permitting bacteria to move across a surface.

Cellular differentiation

Swarming bacteria undergo morphological differentiation that distinguish them from their planktonic state. Cells localized at migration front are typically hyperelongated, hyperflagellated and grouped in multicellular raft structures.

Ecological significance

The fundamental role of swarming motility remains unknown. However, it has been observed that active swarming bacteria of *Salmonella typhimurium* shows an elevated resistance to certain antibiotics compared to undifferentiated cells