Penicillium

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Penicillium (/ˌpɛnɪˈsɪlɪəm/) is a genus of ascomycetous fungi of major importance in the natural environment as well as food and drug production.

Some members of the genus produce penicillin, a molecule that is used as an antibiotic, which kills or stops the growth of certain kinds of bacteria inside the body. Other species are used in cheesemaking. According to the *Dictionary of the Fungi* (10th edition, 2008), the widespread genus contains over 300 species.[2]

Contents

Taxonomy

The genus was first described in the scientific literature by Johann Heinrich Friedrich Link in his 1809 work *Observationes in ordines plantarum naturales*.[3] Link included three species—*P. candidum*, *P. expansum*, and *P. glaucum*—all of which produced a brush-like conidiophore (asexual fruiting structure). The common apple rot fungus *P. expansum* was selected as the type species.[4]

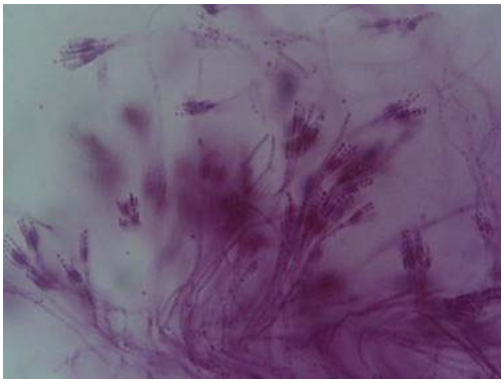
In a 1979 monograph, John I. Pitt divided *Penicillium* into four subgenera based on conidiophore morphology and branching pattern: *Aspergilloides*, *Biverticillium*, *Furcatum*, and *Penicillium*.[5]

Penicillium is classified as a genus of; domain eukaryota kingdom Fungi division Ascomycota (order Eurotiales, class Eurotiomycetes, family Trichocomaceae).[6]

Species

Selected species include;

Penicillium



Penicillium sp.

Scientific classification

Kingdom:	Fungi
Phylum:	Ascomycota
Class:	Eurotiomycetes
Order:	Eurotiales
Family:	Trichocomaceae
Genus:	***Penicillium*** Link (1809)

Type species

Penicillium expansum Link (1809)

Species

over 300
List of Penicillium species

Synonyms[1]

Floccaria Grev. (1827)
Aspergilloides Dierckx (1901)
Walzia Sorokin (1871)
Pritzeliella Henn. (1903)

- *Penicillium albocoremium*
- *Penicillium aurantiogriseum*
- *Penicillium bilaiae*, which is an agricultural inoculant
- *Penicillium camemberti*, which is used in the production of Camembert and Brie cheeses
- *Penicillium candidum*, which is used in making Brie and Camembert. It has been reduced to synonymy with *Penicillium camemberti*
- *Penicillium chrysogenum* (previously known as *Penicillium notatum*), which produces the antibiotic penicillin
- *Penicillium claviforme*
- *Penicillium commune*
- *Penicillium crustosum*
- *Penicillium digitatum* a plant pathogen
- *Penicillium echinulatum* produces Mycophenolic acid
- *Penicillium expansum*, a plant pathogen
- *Penicillium funiculosum*, a plant pathogen
- *Penicillium glabrum*
- *Penicillium glaucum*, which is used in making Gorgonzola cheese
- *Penicillium italicum*
- *Penicillium lacussarmientei*
- *Penicillium marneffei*, a thermally dimorphic species endemic in Southeast Asia, which presents a threat of systemic infection to AIDS patients
- *Penicillium purpurogenum*
- *Penicillium roqueforti*, which is used in making Roquefort, Danish Blue cheese, and also recently Gorgonzola
- *Penicillium stoloniferum*
- *Penicillium ulaiense*
- *Penicillium verrucosum* produces ochratoxin A
- *Penicillium viridicatum* produces ochratoxin

Various fungi including *Penicillium* and *Aspergillus* species growing in axenic culture

Some penicillium mold on mandarin oranges

Etymology

The genus name is derived from the Latin root *penicillum*, meaning "painter's brush", and refers to the chains of conidia that resemble a broom.[7]

Characteristics

The thallus (mycelium) typically consists of a highly branched network of multinucleate, septate, usually colorless hyphae. Many-branched conidiophores sprout on the mycelia, bearing individually constricted conidiospores. The conidiospores are the main dispersal route of the fungi, and often are green in color.

Sexual reproduction involves the production of ascospores, commencing with the fusion of an archegonium and an antheridium, with sharing of nuclei. The irregularly distributed asci contain eight unicellular ascospores each.

Ecology

Species of *Penicillium* are ubiquitous soil fungi preferring cool and moderate climates, commonly present wherever organic material is available. Saprophytic species of *Penicillium* and *Aspergillus* are among the best-known representatives of the Eurotiales and live mainly on organic biodegradable substances.

Commonly known as molds, they are among the main causes of food spoilage, especially species of subgenus *Penicillium*.[8] Many species produce highly toxic mycotoxins. The ability of these *Penicillium* species to grow on seeds and other stored foods depends on their propensity to thrive in low humidity and to colonize rapidly by aerial dispersion while the seeds are sufficiently moist.[9] Some species have a blue color, commonly growing on old bread and giving it a blue fuzzy texture.

Penicillium Spp. under bright field microscopy (10 x 100 magnification) with lactophenol cotton blue stain

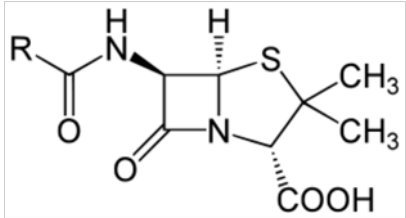
Some *Penicillium* species affect the fruits and bulbs of plants, including *P. expansum*, apples and pears; *P. digitatum*, citrus fruits;[10] and *P. allii*, garlic.[11] Some species are known to be pathogenic to animals; *P. corylophilum*, *P. fellutanum*, *P. implicatum*, *P. janthinellum*, *P. viridicatum*, and *P. waksmanii* are potential pathogens of mosquitoes.[12] *P. marneffei*, which causes mortality in the Vietnamese bamboo rats, has become a common opportunistic infection of HIV-infected individuals in southeast Asia.[13]

Penicillium species are present in the air and dust of indoor environments, such as homes and public buildings. The fungus can be readily transported from the outdoors, and grow indoors using building material or accumulated soil to obtain nutrients for growth. *Penicillium* growth can still occur indoors even if the relative humidity is low, as long as there is sufficient moisture available on a given surface. A British study determined that *Aspergillus*- and *Penicillium*-type spores were the most prevalent in the indoor air of residential properties, and exceeded outdoor levels.[14] Even ceiling tiles can support the growth of *Penicillium*—as one study demonstrated—if the relative humidity is 85% and the moisture content of the tiles is greater than 2.2%.[15]

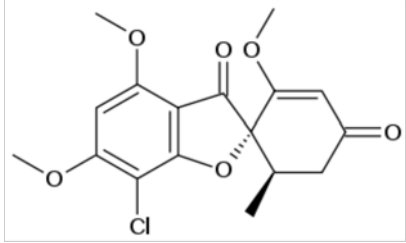
Some *Penicillium* species cause damage to machinery and the combustible materials and lubricants used to run and maintain them. For example, *P. chrysogenum*, *P. steckii*, *P. notatum*, *P. cyclopium*, and *P. nalgiovensis* affect fuels; *P. chrysogenum*, *P. rubrum*, and *P. verrucosum* cause damage to oils and lubricants; *P. regulosum* damages optical and protective glass.[16]

Economic value

Several species of the genus *Penicillium* play a central role in the production of cheese and of various meat products. To be specific, *Penicillium* molds are found in Blue cheese. *Penicillium camemberti* and *Penicillium roqueforti* are the molds on Camembert, Brie, Roquefort, and many other cheeses. *Penicillium nalgiovense* is used to improve the taste of sausages and hams, and to prevent colonization by other molds and bacteria.[17]



Core structure of penicillin



Griseofulvin

In addition to their importance in the food industry, species of *Penicillium* and *Aspergillus* serve in the production of a number of biotechnologically produced enzymes and other macromolecules, such as gluconic, citric, and tartaric acids, as well as several pectinases, lipase, amylases, cellulases, and proteases. Some *Penicillium* species have shown potential for use in bioremediation because of their ability to break down a variety of xenobiotic compounds.[18]

The genus includes a wide variety of species molds that are the source

molds of major antibiotics. Penicillin, a drug produced by *P. chrysogenum (formerly P. notatum),* was accidentally discovered by Alexander Fleming in 1929, and found to inhibit the growth of Gram-positive bacteria (see beta-lactams). Its potential as an antibiotic was realized in the late 1930s, and Howard Florey and Ernst Boris Chain purified and concentrated the compound. The drug's success in saving soldiers in World War II who had been dying from infected wounds resulted in Fleming, Florey and Chain jointly winning the Nobel Prize in Medicine in 1945.[19]

Griseofulvin is an antifungal drug and a potential chemotherapeutic agent[20] that was discovered in *P. griseofulvum*.[21] Additional species that produce compounds capable of inhibiting the growth of tumor cells *in vitro* include: *P. pinophilum*,[22] *P. canescens*,[23] and *P. glabrum*.[23]

Reproduction

Although many eukaryotes are able to reproduce sexually, as much as 20% of fungal species had been thought to reproduce exclusively by asexual means. However recent studies have revealed that sex occurs even in some of the supposedly asexual species. For example, sexual capability was recently shown for the fungus *Penicillium roqueforti*, used as a starter for blue cheese production.[24] This finding was based, in part, on evidence for functional mating type (MAT) genes that are involved in fungal sexual compatibility, and the presence in the sequenced genome of most of the important genes known to be involved in meiosis. *Penicillium chrysogenum* is of major medical and historical importance as the original and present-day industrial source of the antibiotic penicillin. The species was considered asexual for more than 100 years despite concerted efforts to induce sexual reproduction. However, in 2013, Bohm et al.[25] finally demonstrated sexual reproduction in *P. chrysogenum*.

Penicillium marneffei, an AIDS-associated pathogen, was also previously assumed to reproduce exclusively by asexual means. This assumption was largely based on the highly clonal population structure of this species. However, recent work has revealed that the genes required for meiosis are present in *P. marneffei*.[26] This and other evidence indicated that mating and genetic recombination does occur in this species. It was concluded that *P. marneffei* is sexually reproducing, but recombination is most likely to occur across spatially and genetically limited distances in natural populations resulting in a highly clonal population structure.[26]

These findings with *Penicillium* species are consistent with accumulating evidence from studies of other eukaryotic species that sex was likely present in the common ancestor of all eukaryotes.[27][28] Furthermore, these recent results suggest that sex can be maintained even when very little genetic variability is produced.

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External links

- Samson, R. A. & J I Pitt *Integration of Modern Taxonomic Methods For Penicillium and Aspergillus Classification* (with an illustration on the cover) (http://books.google.com/books?id=3KJewsIL5vQC&pg=PA66&dq=genus+penicillium#v=onepage&q=genus%20penicillium&f=false)
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