Fungi
Mycobionta

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Meeres

Fungi, Mycobionta, Mycetes, Pilze

Mushroom, Champignon, Hutpilz

Mould or mold, Schimmel

Yeast, Hefe

General life mode of fungi

- Osmotrophic (absorptive) life mode
- Chemoorganoheterotroph, normally aerobe
- Tolerant to acids (acidotolerant or acidophilic) and dryness (xerotolerant or xerophilic)
- Growth in filamentous structures assures large contact surface with substrate or other organisms
- In soil, fungi accounts for up to 75% of the living biomass.

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Different habitats and "relationships"

- Saprophytes (Saprobionts):
  - Soil (1g contains 10 - 100 m of fungal mycelium)
  - Wood (degradation and discoloration)
  - All kinds of organic material
  - Inorganic material as substratum
- Parasites
  - On plants, algae, animals
- Symbionts
  - With plant roots (mycorrhiza), algae, cyanobacteria (lichens)

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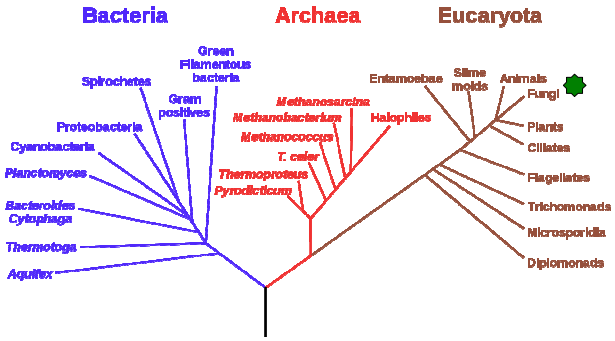
Position in the tree of life



http://en.wikipedia.org/wiki/File:Phylogenetic_tree.svg

Oomycetes and Slime molds

- **Fungi-like protists, no** cell wall with **chitin**
- **Oomycetes** (Algal fungi, Cellulose fungi, e.g. *Saprolegnia*)
- **Myxobionta** (slime molds), amoebae without cell wall

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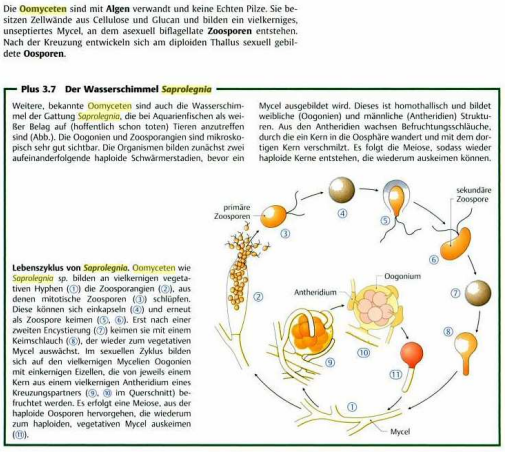
Oomycetes

- **Oomycetes** (Algal fungi, Cellulose fungi, e.g. *Saprolegnia*)
  - Heterokontobionta (protists, two types of flagella), some phototrophic



Die **Oomyceten** sind mit **Algen** verwandt und keine Echten Pilze. Sie besitzen Zellwände aus Cellulose und Glucan und bilden ein vielkerniges, unseptiertes Mycel, an dem asexuell biflagellate **Zoosporen** entstehen. Nach der Kreuzung entwickeln sich am diploiden Thallus sexuell gebildete **Oosporen**.

Plus 3.7 Der Wasserschimmel *Saprolegnia*

Weitere, bekannte Oomyceten sind auch die Wasserschimmel der Gattung *Saprolegnia*, die bei Aquarienfischen als weißer Belag auf (hoffentlich schon toten) Tieren anzutreffen sind (Abb.). Die Oogonien und Zoosporangien sind mikroskopisch sehr gut sichtbar. Die Organismen bilden zunächst zwei aufeinanderfolgende haploide Schwärmerstadien, bevor ein Mycel ausgebildet wird. Dieses ist homothallisch und bildet weibliche (Oogonien) und männliche (Antheridien) Strukturen. Aus den Antheridien wachsen Befruchtungsschläuche, durch die ein Kern in die Oosphäre wandert und mit dem dortigen Kern verschmilzt. Es folgt die Meiose, sodass wieder haploide Kerne entstehen, die wiederum auskeimen können.

primäre Zoosporen
sekundäre Zoospore
Oogonium
Antheridium
Mycel

Lebenszyklus von *Saprolegnia*. Oomyceten wie *Saprolegnia* sp. bilden an vielkernigen vegetativen Hyphen (①) die Zoosporangien (②), aus denen mitotische Zoosporen (③) schlüpfen. Diese können sich einkapseln (④) und erneut als Zoospore keimen (⑤, ⑥). Erst nach einer zweiten Encystierung (⑦) keimen sie mit einem Keimschlauch (⑧), der wieder zum vegetativen Mycel auswächst. Im sexuellen Zyklus bilden sich auf den vielkernigen Mycelien Oogonien mit einkernigen Eizellen, die von jeweils einem Kern aus einem vielkernigen Antheridium eines Kreuzungspartners (⑨, ⑩) im Querschnitt befruchtet werden. Es erfolgt eine Meiose, aus der haploide Oosporen hervorgehen, die wiederum zum haploiden, vegetativen Mycel auskeimen (⑪).

Aus Fuchs, Schlegel, Allgemeine Mikrobiologie

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Slime molds

Blade of grass from Bert Engelen's garden

die-welt-der-schleimpilzemyxomyceten.html

Myxobionta (slime molds), amoebae without cell wall

- **real** slime molds form polykaryotic **plasmodia**
- **cellular** slime molds form multi-cellular **pseudo-plasmodia**

  do not mix up with **Myxobacteria**

  (also form multi-cellular aggregates and fruiting bodies)

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Chitin fungi (true fungi)

- Eukaryotes
- Immobile (exceptions)
- Uni- or multi-cellular with cell wall
- Organoheterotrophic life mode, saprophytic, parasites or symbionts, osmotrophic, aerobes
- App. 120 000 species (up to 1.5 mio.?), few pathogens

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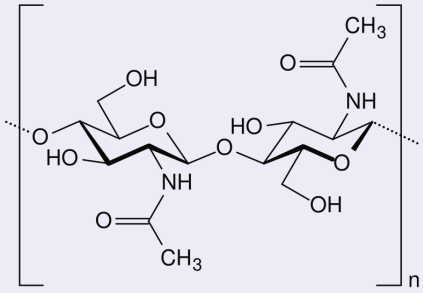
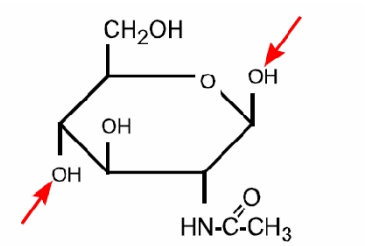
Chitin

- Important component of the cell wall (together with glucanes and proteines
- Polymer of **N-Acetyl-Glucosamine**
- Also found in insects

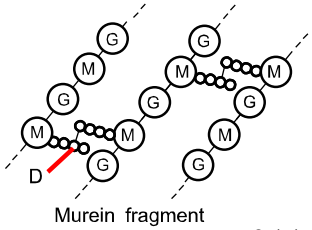


www.wikipedia.de



N-Acetyl-Glucosamin (G)

- also component of bacterial cell wall



Murein fragment

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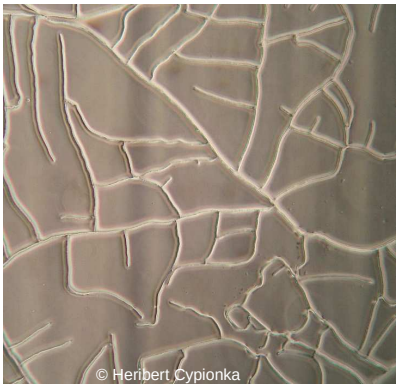
Hyphae, mycelium

- Cell wall composed mainly of chitin, glucane polymers, proteins and pigments, e.g. melanin
- Hyphae with a diameter of 1 to 10 µm, growth at tip
- Mycelium (= network of hyphae) penetration of substrate and increase of surface



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Fungi and their fruiting bodies

- Macroscopic mushrooms – only the fruiting bodies
- Network of microscopic hyphae
- "Function" of fruiting bodies: Protection and distribution of spores
- Periodic growth and formation of fruiting bodies fairy rings "Hexenringe"

www.wikipedia.de

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Spores

- Distribution- and resting stages
- Asexual or ...
- Sexual: after mating of cells and alternation of nuclear phase (haploid/diploid; mostly in fruiting bodies)
- Both types of spores occur in different stages of the life cycle
- Can cause allergic reactions

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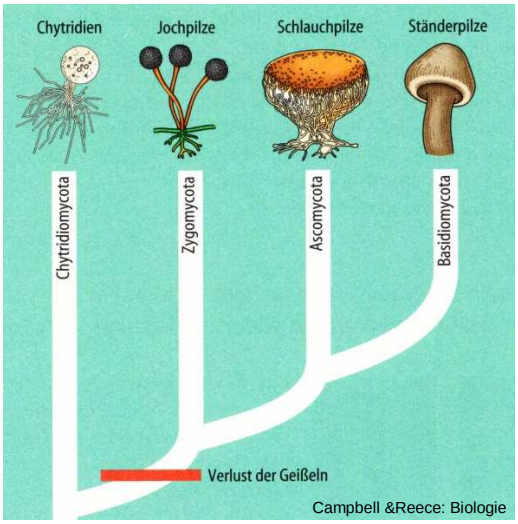
Phylogeny of fungi (Mycobionta)

- Differences in reproduction, especially time of meiosis and meiotic spores
- Alternation of nuclear phases, alternation of generations
- Morphological characteristics proven by molecular data



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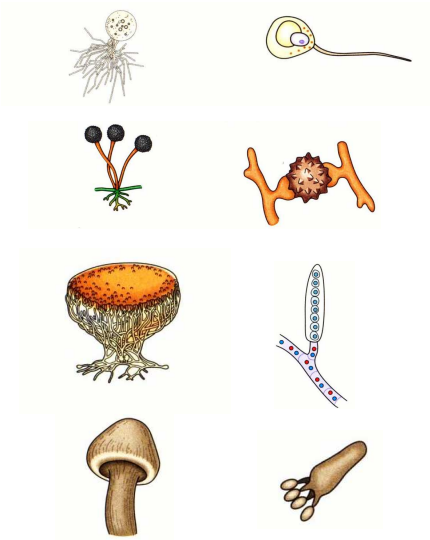
Groups of (true) fungi

- Chytridiomycetes (flagella fungi)
  Spores with flagellum
- Zygomycetes (black bread molds)
  Zygosporangium as sexual state
- Ascomycetes (sac fungi)
  Sexual spores in sacs
- Basidiomycetes (club fungi)
  Sexual spores at basidia



Campbell &Reece: Biologie

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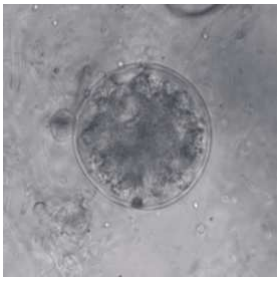
Chytridiomycota

- "Flagellaten- or Töpfchenpilze"
- Have flagellated gametes (zoospores)
- Small, “primitive group“ (app. 500 species), anaerobes
- Mostly aquatic (origin of fungi?)



www.wikipedia.org

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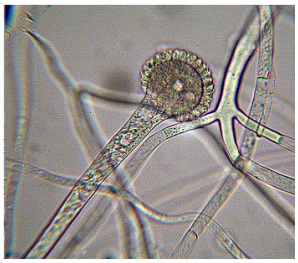
Zygomycota (Jochpilze)

- Example *Rhizopus*,

  "gemeiner Brotschimmel"
- Reproduce sexually via zygospores
- Some are parasites of insects
- Some are symbionts (mycorrhiza)



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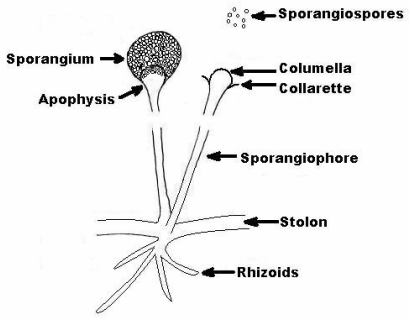

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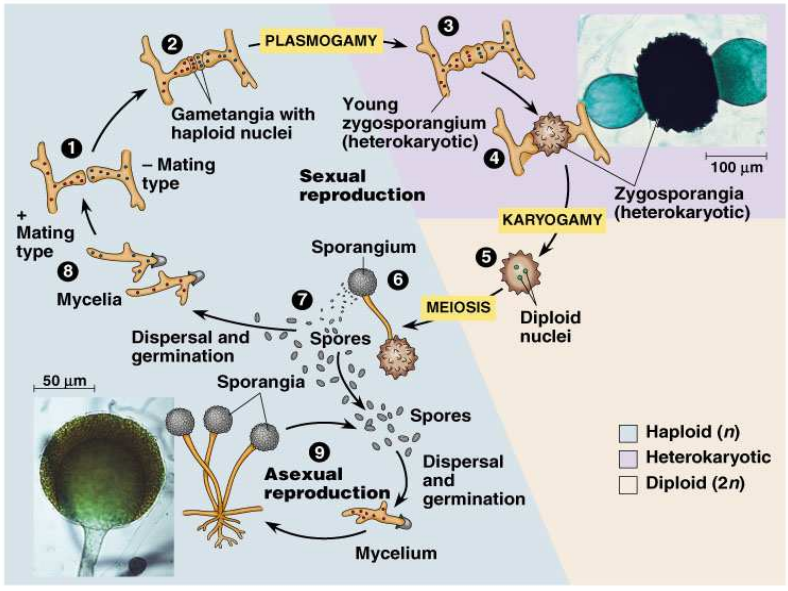
Life cycle of Zygomycota (Jochpilze)



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Ascomycota (Schlauchpilze)

- Biggest group (> 60 000 species), small organisms
- **Saprophytes**

  or **Parasites** (e.g. 'Powdery mildew' (Echter Mehltau),

  or **Symbionts** (lichens, mycorrhiza)
- Spores: asexual – exogenous;

  sexual – in Ascocarp (dikaryotic)

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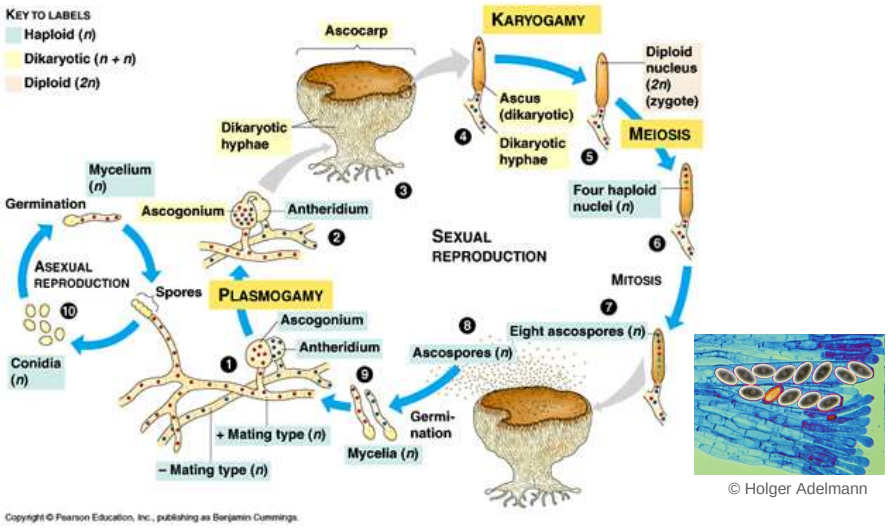
Life cycle of Ascomycetes



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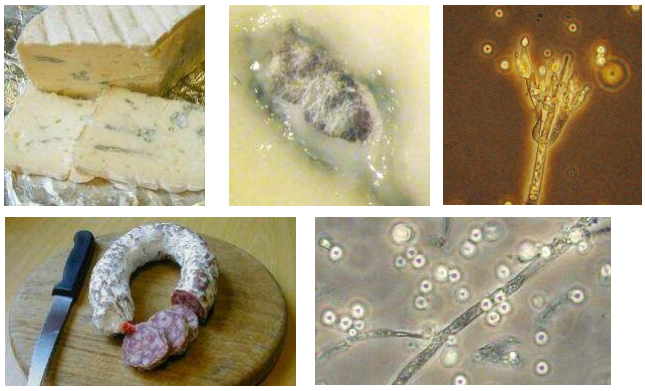
Penicillium roquefortii

- "Pinselschimmel, Edelschimmel“
- Some *Penicillium* species produce antibiotics



www.mikrobiologischer-garten.de

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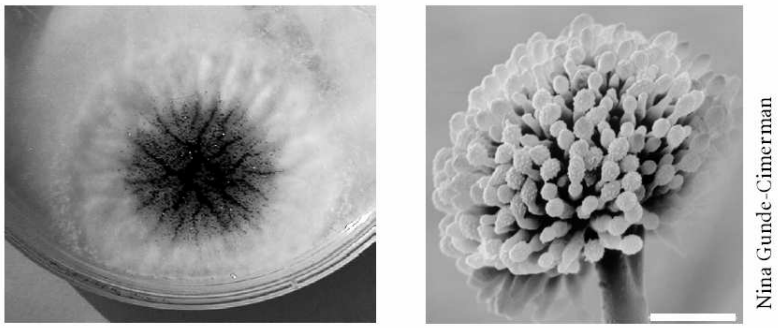
Aspergillus

- "Gießkannenschimmel"
- Can cause allergic reactions



Nina Gunde-Cimerman

Abb. 4.3. Der Gießkannenschimmel *Aspergillus* gehört zu den Ascomyceten. *Links* eine Kolonie auf einer Agarplatte, *rechts* ein Sporangium mit Sporen unter dem Raster-Elektronenmikroskop (Maßstab = 20 µm) Cypionka, Grundlagen der Mikrobiologie, 3. Aufl.

Cypionka, www.pmbio.icbm.de

Mushrooms (Basidiomycota)

- Chitin in cell wall
- Haploid -> dikaryotic mycelium -> fruiting body
- Spores exogenic at basidium (located at fruiting body)
- Saprophytes, parasites, symbionts

www.wikipedia.de

Agaric ("Blätterpilz")

- Example: *Amanita muscaria* ("Fliegenpilz")
- Related to "Pantherpilz" and "Knollenblätterpilz"
- Poison in red scin of the cap, halluzinogenic (Berserker)

Boletus ("Röhrling")

- Example: *Boletus edulis* ("Steinpilz")
- Eatable, do not mix-up with the "Gallenröhrling"

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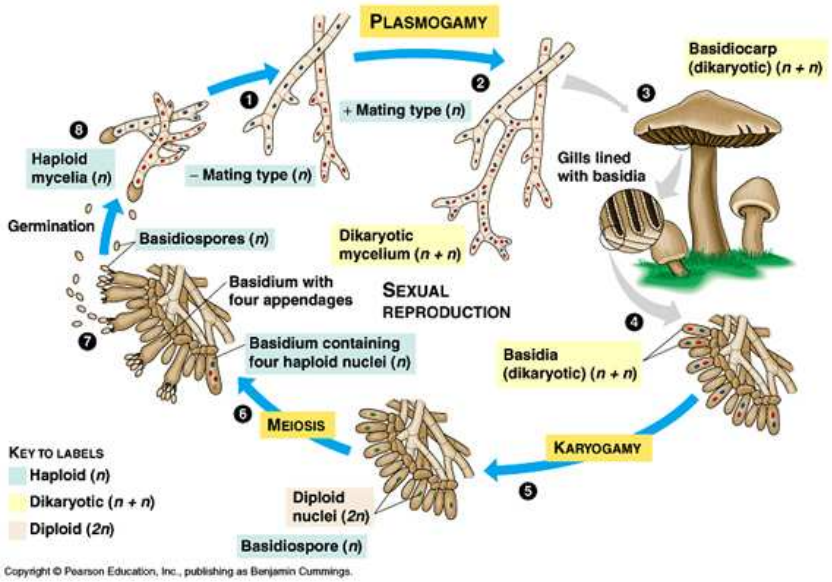
Life cycle of Basidiomycetes



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Deuteromycetes or "Fungi imperfecti"

- **It is not the fungi that are imperfect, it is us, the scientists!**
- Fungi without known sexual reproduction stages
- Can be ascomycetes or basidiomycetes
- Examples: yeast, ergot fungi ("Mutterkorn"), athlete's foot ("Fußpilz")



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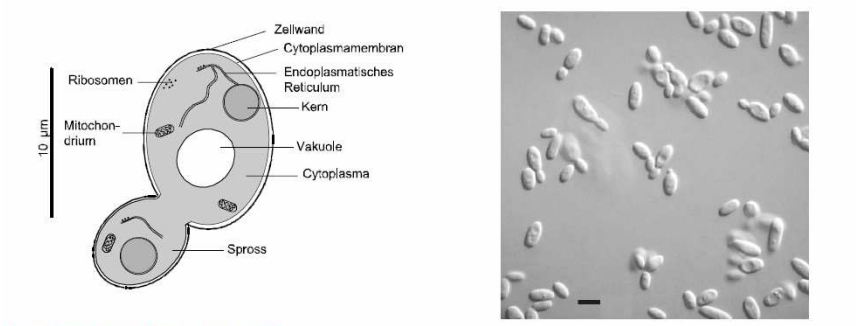
Example yeast

- Can be ascomycetes or basidiomycetes
- *Saccharomyces cerevisiae (Ascomycete)*, fermentation



Cypionka, Grundlagen der Mikrobiologie, 3. Aufl.

Abb. 4.4. Hefezellen. *Links* der Aufbau einer sprossenden Zelle schematisch, *rechts* ein Präparat unter dem Mikroskop. Im differenziellen Interferenzkontrast (s. Kap. 6) erscheinen die Zellen und innere Strukturen reliefartig räumlich. Maßstab = 10 µm

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Baker's yeast

• What is yeast doing in the kitchen?

• What is it doing in the brewery and during wine production?

• $C_6H_{12}O_6 \rightarrow 2\ CO_2 + 2\ C_2H_5OH$

Cypionka, www.pmbio.icbm.de

Example parasite

Claviceps purpurea

- *Ergot fungus,* Ascomycete

- Only one grain is infected (in flower)

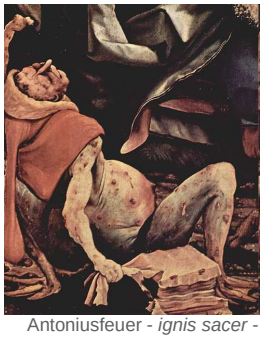
- Resting stage (over winter),

  fruiting bodies are formed afterwards (meiotic spores)

-Many secondary metabolites (Alkaloids, hallucinogenic fungi, LSD)

- **Mycotoxins** of other fungi: e.g. **Afla**toxin (**A**spergillus **fla**vus) on stored peanuts and cereals

Ergot on wheat spikes
www.wikipedia.com



Antoniusfeuer - *ignis sacer* -
Isenheimer Altar in Colmar

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Example parasite: Dermatomycosis

Ort:	Köln				
Teilnehmergruppe:	Sportstudierende, Laufsportler				
Anzahl der Teilnehmer insgesamt:	94	**männlich:**	54		
		weiblich:	40		
Alter der Teilnehmer, Mittelwert:	22,8 Jahre	**MIN:**	18 Jahre		
		MAX:	30 Jahre		
Mykologische Infektionsrate insgesamt:		61,7	%		
Tinea pedis interdigitalis:		45,7	%		
Onychomykose:		40,4	%		
Tinea pedis (Mokassin-Typ):		11,7	%		
Erregerspektrum „Füße":	Trichophyton rubrum			65,7	%
	T. mentagrophytes var. interdigitale			34,2	%
	Epidermophyton floccosum			13,2	%
Schuhuntersuchungen:	35,4 % kontaminierte Schuhe				
Erregerspektrum „Schuhe":	Trichophyton mentagrophytes			51,5	%
	Trichophyton rubrum			33,3	%
	Epidermophyton floccosum			9,1	%

www.wikipedia.de

Jan Ries (2002) Mykosen und Sport – Verbreitung von Mykosen bei Sportschuh-tragenden Sportlern. Dissertation, Univ. Frankfurt

Cypionka, www.pmbio.icbm.de

Symbiotic fungi

- **Mycorrhiza** – Symbiosis with higher plants (trees, grass)
- **Lichens** – Symbiosis with algae and/or cyanobacteria

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Mycotrophy of plants

- 80% of all plants are obligate mycotrophs,10% facultative mycotrophs
- Fungi grow in close contact with the plant root
  - within the cell
  - as fungal sheath around the root
- Characteristic morphology
- Complementary benefit:

Water, P-, N- and Ca-components for the plant (function of haustorium is transferred to hyphae),

Assimilated carbohydrates for the fungus

www.wikipedia.de
Root tips with mycorrhiza sheat

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Lichens (Flechten)



- Different substrates
  - Wood, trees
  - Rocks, glas, soil
  - Leaves (tropical)
- Not competitive in many environments due to low growth rate
- At extreme sites with short vegetation periods (desert, mountains, permafrost, tundra); often predominant over plants
- In the tundra, main vegetation as photosynthesis even starts a low temperatures

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Lichens

- Dual organisms
- Photobiont: green alga or cyanobacteria
- Mycobiont: asco- or basidiomycete
- Photobionts also occur free living
- Mycobiont regulates shape and reproduces sexually
- Contact: Cell wall/cell wall or Cell membrane/cell membrane
  - Body (thallus):
    - Cortex
    - Layer of photobionts and
    - Medula
  - Habit (shape)
    - Crustal lichens
    - Leaf lichens
    - Bush lichens

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Different habits of lichens

Crustal lichens

- Located close to substratum
- Contain only upper cortex
- Growing zone at border

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Leaf lichens

- Lies only loose on substratum
- Protected via upper and lower cortex
- Growing zone at border of "leaf"

www.wikipedia.de

Bush or beard lichens

- Bush-like, cross section is round
- Cortex around the lichen
- Growing zone at end of branches
- Only in areas with clean air,
- sensitive against air pollution

www.wikipedia.de

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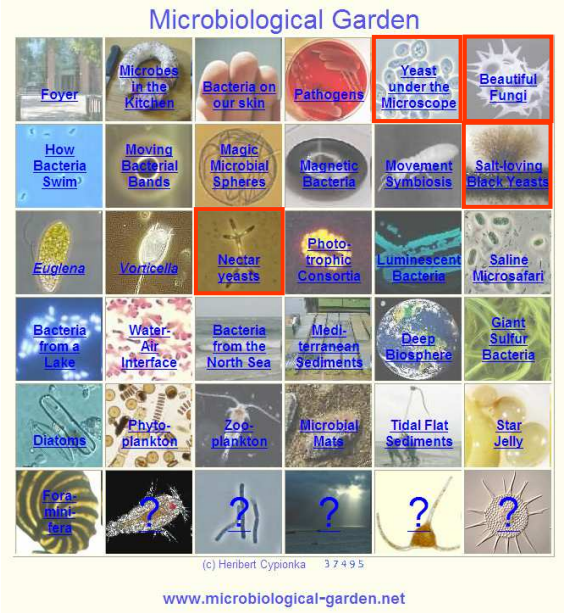
www.microbiological-garden.net



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