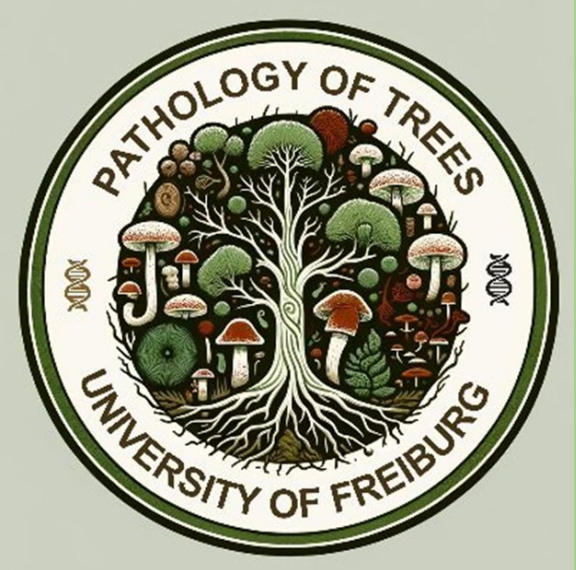


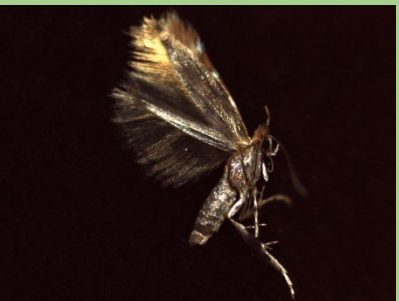


FOREST PATHOLOGY

02.06.25 – 27.06.25

at the Chair of Pathology of Trees

Lecturers: Yasin Korkmaz and Kathrin Blumenstein



White and brown rot fungi

Lecture 11



K. Blumenstein





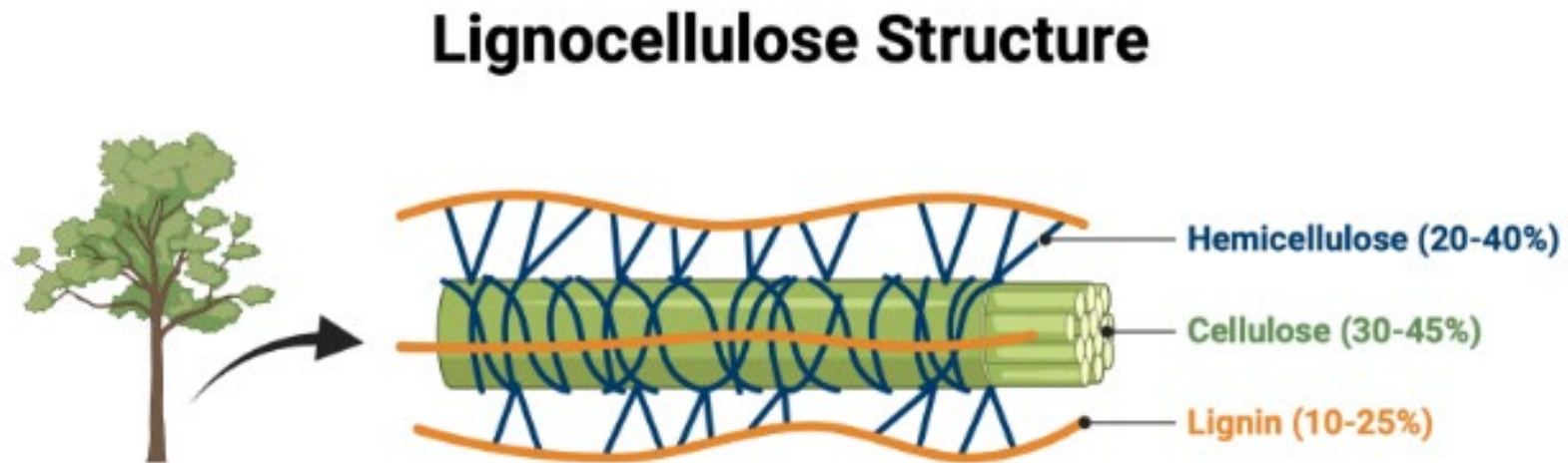
What is the main job of fungi in the ecosystem?



→ Fungi are wood decomposers = destruent / saprotrophs

Fungi in their life form as saprotrophs are the most important decomposers of the wood body composed of cellulose and lignin.

Structure of the wall of wood cells





Fungi as wood decomposers - two types of rot

1) Brown rot

- Cellulose and hemicellulose (the polysaccharides in the cell wall) are decomposed
- the lignin skeleton remains intact
- Oxygen from the air alters the lignin components (oxidative process), causing them to take on a brown-red coloration.
- Brown rot wood is cracked and crumbly and can be crumbled between the thumb and forefinger in the final stage.



Fungi as wood decomposers - two types of rot

2) White rot

- First, the lignin is broken down by the enzymes of the decomposing fungi
- The remaining cellulose is very lightly colored
- Fibrous structure, very light and spongy
- Later, the cellulose is also decomposed by these fungi.



Wood Decay Fungi - Fruting bodies and specialties



<https://esj-journals.onlinelibrary.wiley.com/doi/full/10.1111/1440-1703.12260>

Fomitopsis pinicola – Red-belted conk



<http://www.biopix-foto.de/zoom.aspx?photoid=114568>

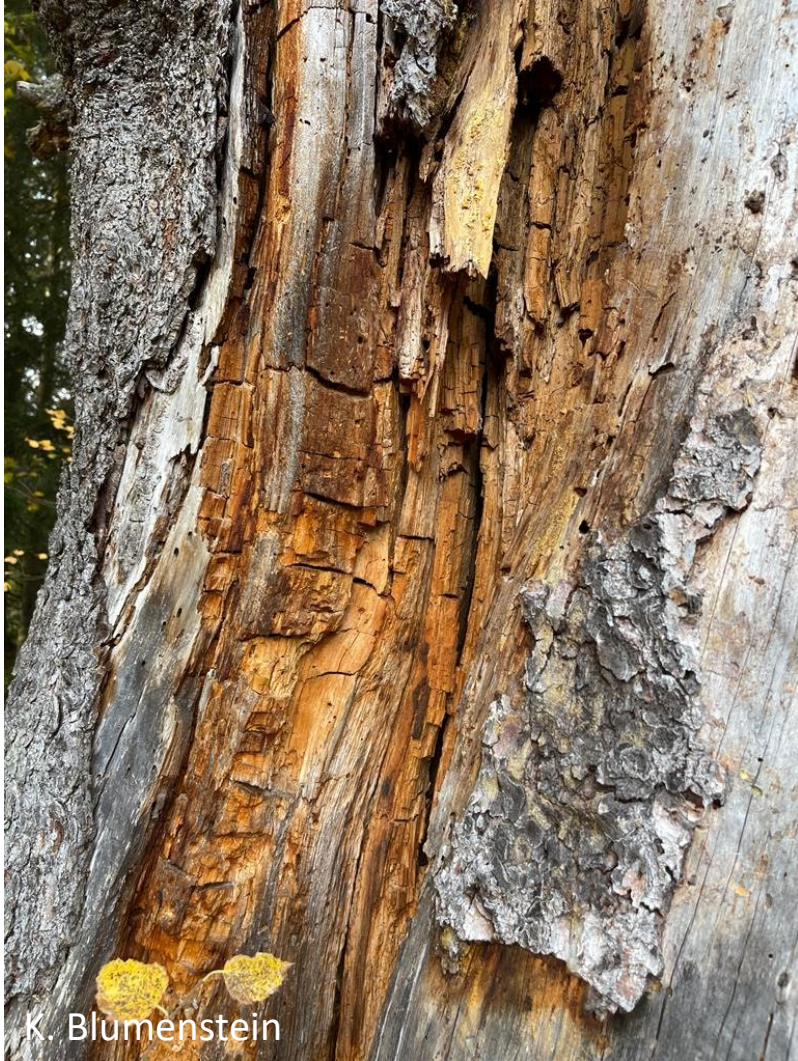
- perennial fruiting bodies are somewhat smaller than those of the tinder fungus and are blackish on top with a red edge when fully grown
- when exposed to heat (match), its upper side melts, which is not the case with the tinder fungus.

Fomitopsis pinicola – Red-belted conk

- Ancestral
- often colonizes the beech together with the tinder fungus
- However, the areas are clearly defined in the wood
- Most common colonizer of dead coniferous wood in the mountains (e.g. “spruce spore”); at lower altitudes rather on deciduous wood (mostly beech)



Fomitopsis pinicola – Red-belted conk



- Causing brown rot

Fomitopsis pinicola – Red-belted conk



- guttation

Ganoderma sp.

varnish-like to resinous crust

Fruiting bodies are perennial

Intense white rot in the root and stock area of hardwoods (rarely conifers) and can also cause cambium damage (canker rot)

Ganoderma species are brown spores, i.e. the surroundings and often also the upper side are covered with brown spore dust



http://www.pflanzenliebe.de/innen/innen_pilze/innen_flacher_lackporling.html



<https://www.123pilze.de/000Forum/board/index.php?thread/11268-flacher-lackporling/>

Ganoderma applanatum (Flat Varnish Porling)



upperside

underside

Host: Hardwood (various species)

Fruiting Body: Perennial

Rot: Selective white rot; occasionally simultaneous white rot on root/rhizome, often with teat galls on underside (teat gall fly) crust depressible, trauma with whitish mycelium veins



- Artists use these mushrooms for freshly etched designs, landscapes, and other paintings when dried. They can be displayed differently than most paintings because the mushroom will stand on its edge on a table or shelf.
- They become almost as hard as a wood block and last many years.



<https://x.com/MycoRoo?s=20>



@Paul Baxendale

This tough bracket lives for many years, developing noticeable annual growth ridges on the upper surface



https://www.inaturalist.org/guide_taxa/511227

The Yellow Flat-footed platypezid fly *Agathomyia wankowiczii* creates distinctive galls on the upper and/or lower surfaces of *Ganoderma applanatum*. Whenever you find a bracket with these galls, any doubt you might have as to whether it is Artist's Bracket *Ganoderma applanatum*

Underside often together with gall fly



<https://bladmineerders.nl/parasites/animalia/arthropoda/insecta/diptera/brachycera/platypezidae/agathomyia/agathomyia-wankowiczii/>

Agathomyia wankowiczii



<https://insektarium.net/diptera-2/platypezidae-urodkowate/agathomyia-wankowiczii-czarka-pomaraneczowa/>

Inonotus hispidus (Shaggy Schiller Porling)



<https://totallywilduk.co.uk/2024/12/24/shaggy-bracket/>

Young Fruiting Body with a downy top and guttation drops on the underside

Host: Hardwood (Ash, Walnut, Sycamore, Oak, Elm, Apple)

Fruiting Body: Annual, summer

Rot: White and soft rot “Dual wood decomposition strategy”
heartwood → about pruning wounds



https://picturemushroom.com/de/wiki/Inonotus_hispidus.html

Effects of *Inonotus hispidus* extracts and compounds on human immunocompetent cells

October 2017 · [Planta Medica International Open](#) · 4

DOI: [10.1055/s-0037-1608591](#)

 Carsten Gründemann ·  M Arnhold ·  S Meier ·  Ulrike Lindequist

Antiviral activity of *Inonotus hispidus*

[N.A. Awadh Ali](#)^{a b}, [R.A.A. Mothana](#)^{a b}, [A. Lesnau](#)^c, [H. Pilgrim](#)^a, [U. Lindequist](#)^a  

The antitumor effect of mycelia extract of the medicinal macrofungus *Inonotus hispidus* on HeLa cells via the mitochondrial-mediated pathway

[Shao-Jun Tang](#), [Chen-Xia Shao](#), [Yi Yang](#), [Rui Ren](#), [Lei Jin](#), [Dan Hu](#), [Shen-Lian Wu](#), [Pin Lei](#), [Yue-Lin He](#), [Jun Xu](#)  

Diverse Metabolites and Pharmacological Effects from the Basidiomycetes *Inonotus hispidus*

[Zhen-xin Wang](#)^{1,†}, [Xi-long Feng](#)^{1,†}, [Chengwei Liu](#)², [Jin-ming Gao](#)¹ and [Jianzhao Qi](#)^{1,*}

- *Inonotus hispidus* is an edible and medicinal mushroom, widely used as a healthcare product and ancient medicinal material in East Asian countries, especially China.
- Previous chemical studies showed it produced a series of active compounds such as polysaccharides, polyphenols, triterpenes, sterols, and melanin.
- Recent investigations have revealed that fruiting body extracts of *Inonotus hispidus* have antitumor, antiviral, immunomodulatory, antioxidant, and hypolipidemic activities.
- Eastern Asia: cancer, diabetes, stomach problems
- Lowering blood glucose level

Trametes versicolor (Butterfly Tramete / Turkey Tail)



Host: Hardwood (mainly Red beech, less common Birch, Poplar, Willow, Linden, Hazel, rarer on coniferous wood)

Fruiting Body: Annual (occurrence may-August)

Rot: Simultaneous white rot



<https://rainbo.com/blogs/blog/turkey-tail>



https://www.mushroomexpert.com/trametes_versicolor.html

This very variable fungus grows mainly on dead hardwood, including stumps, standing dead trees, and fallen branches. Some specimens are strikingly vivid in their coloring.



- Its medicinal value as part of Chinese traditional medicine dates back at least 2000 years and includes general health-promoting effects including endurance and longevity.
- Both in China and Japan, preparations such as dried powdered tea of the fungus are employed in traditional medicine practices.
- In this communication, the main components of the fungi, polysaccharides, have given the fungi its medicinal value in cancer therapy.



https://www.freepik.com/premium-photo/trametes-versicolor-beautiful-fungus-that-grows-dead-wood_20195813.htm

Pleurotus ostreatus (oyster mushroom)

Host: Hardwood (Red beech, Linden, Maple, Poplar, Willow, Horse Chestnut)

Fruiting Body: Annual, from November until February

Rot: Simultaneous white Rot about wounds → stem/crown area

Popular in commercial mushroom cultivation
Low fat- higher fiber



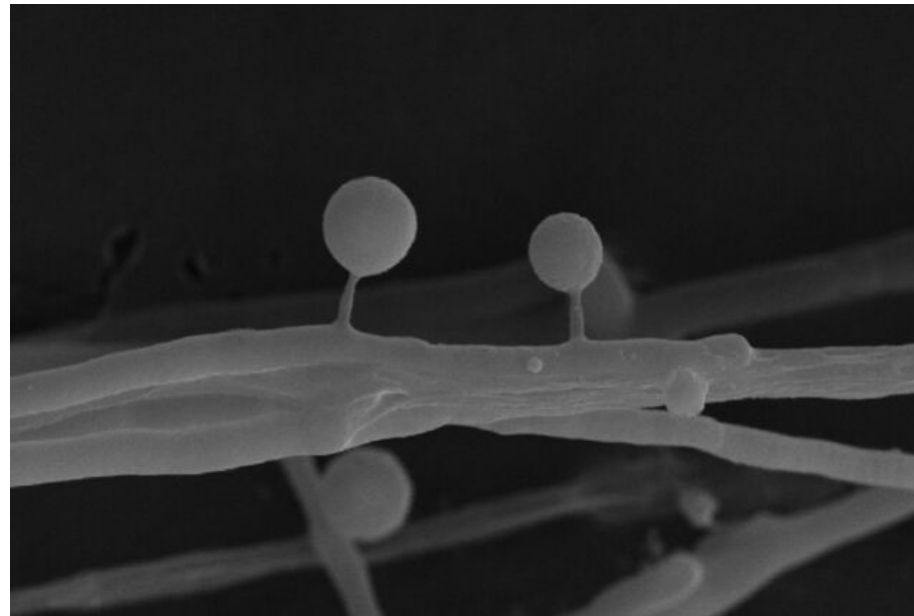
A carnivorous mushroom paralyzes and kills nematodes via a volatile ketone

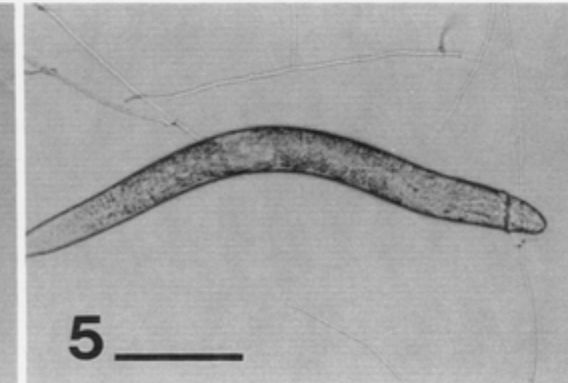
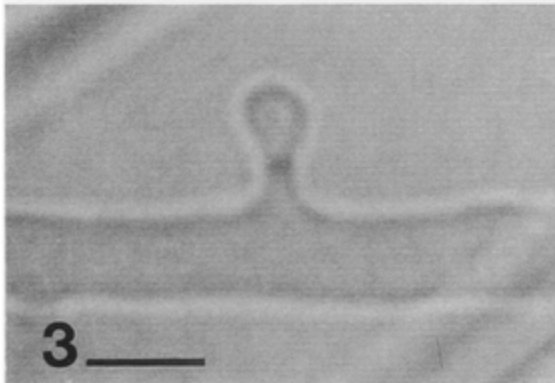
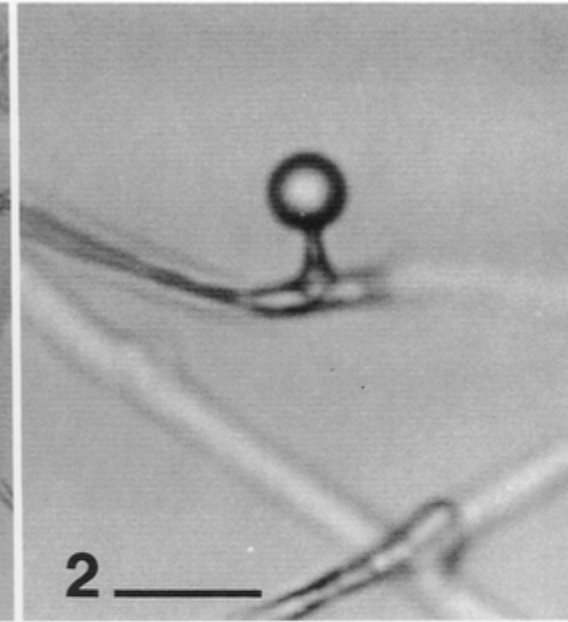
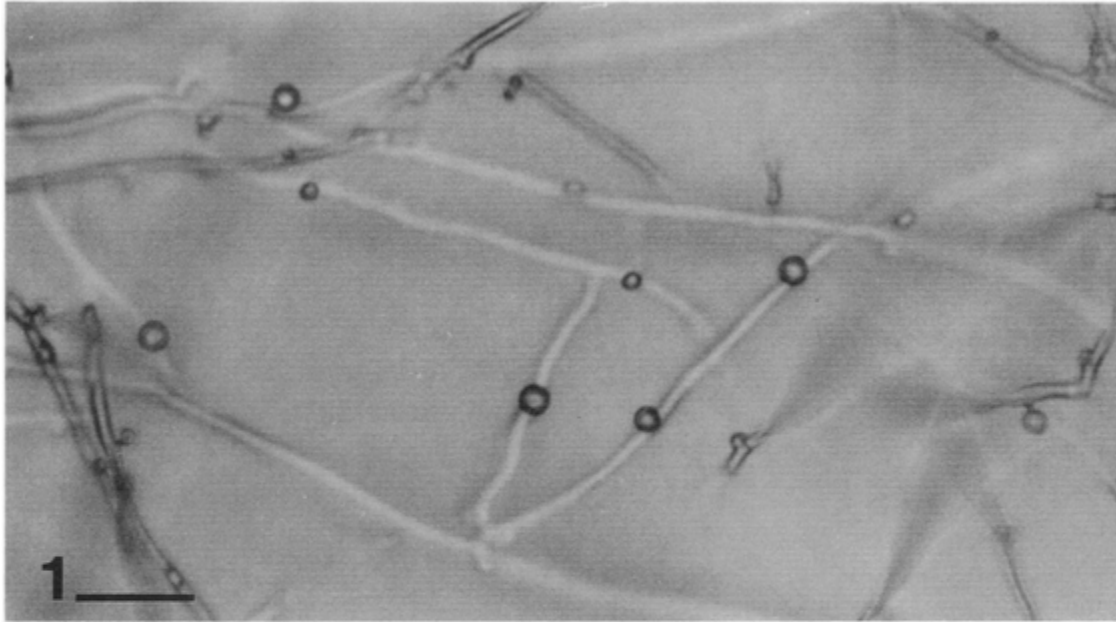
CHING-HAN LEE , YI-YUN LEE , YU-CHU CHANG , WEN-LI PON , SUE-PING LEE , NIAZ WALI, TAKEHITO NAKAZAWA, YOICHI HONDA, JIUN-JIE SHIE , AND

YEN-PING HSUEH  [Authors Info & Affiliations](#)

In the 1980s, scientists discovered that oyster mushrooms are carnivores. The delicious, inescapable inference is that they're the only vegan food that can itself eat meat.

The mushrooms have evolved a novel mechanism for paralyzing and killing its nematode prey: a toxin contained within lollipop-like structures called oocysts that, when emitted, cause widespread cell death in roundworms within minutes.



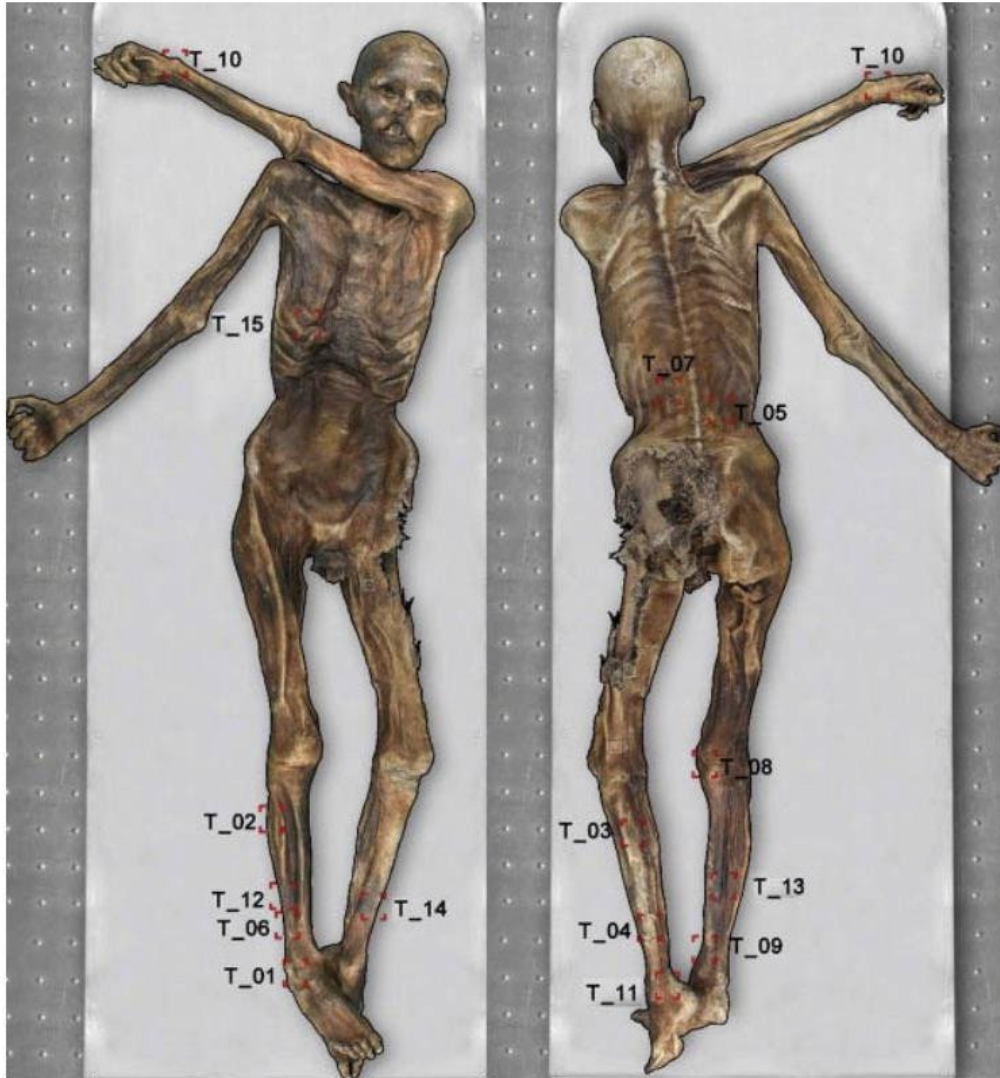


@R Greg Thorn



Ötzi the Iceman

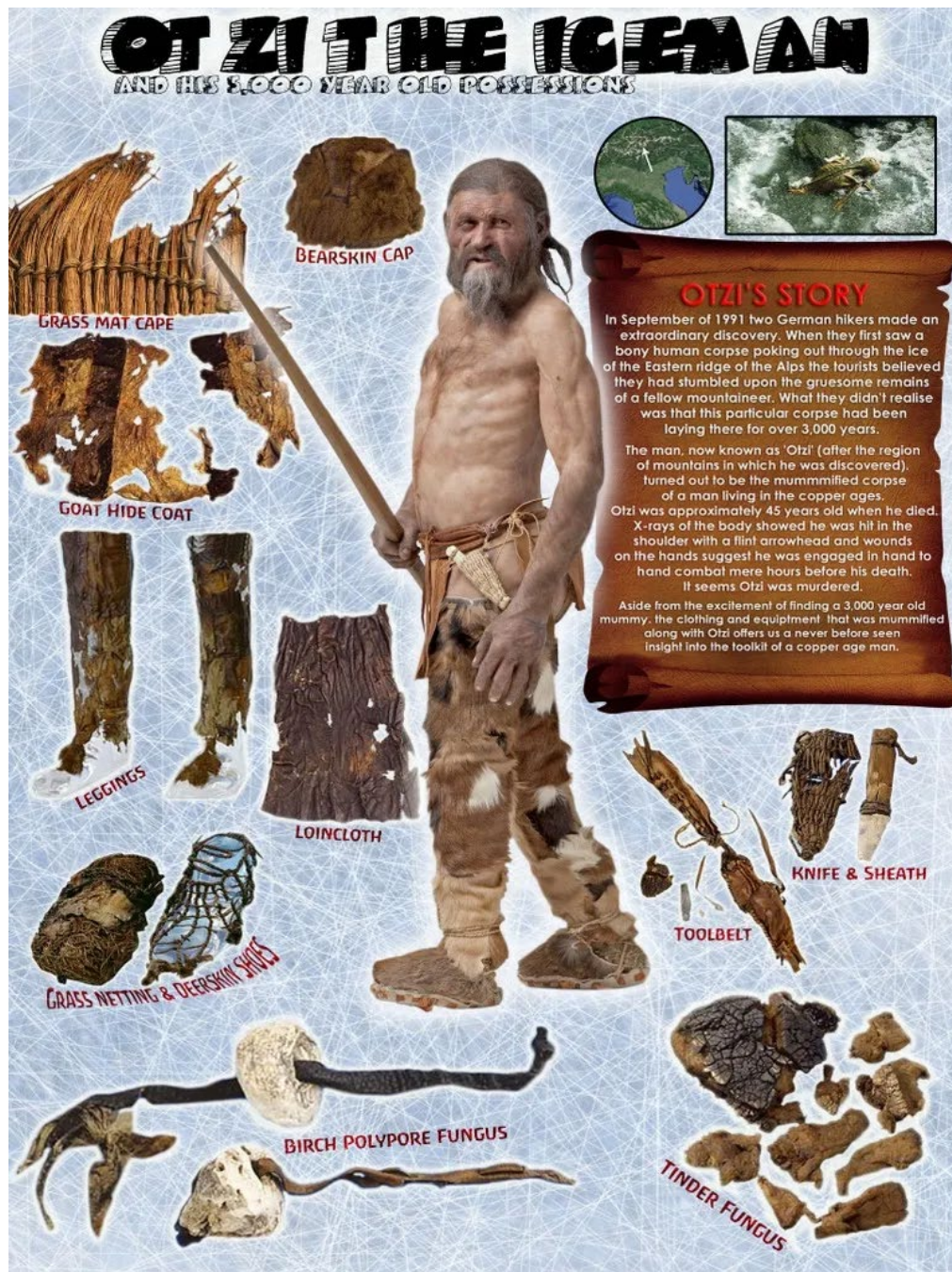
- Ötzi is a glacier mummy from the Copper Age who, thanks to extraordinary circumstances, has been preserved down to the present day.
- He was discovered accidentally by hikers in 1991, together with his clothing and equipment, on the Schnalstal/Val Senales Valley glacier and has been the subject of intensive research ever since.



This graphic shows the general location of each of the 61 tattoos on the Iceman's body. (Photograph © South Tyrol Museum of Archeology/EURAC/Samadelli/Staschitz.)

A man from another era

- Over 5300 years ago, Ötzi was crossing Tisenjoch/Giogo di Tisa in the Schnalstal/Val Senales Valley, South Tyrol, where he was murdered and preserved naturally in the ice.
- He is, therefore, older than the Egyptian pyramids and Stonehenge and the result of a series of highly improbable coincidences.
- Ötzi lived during the Copper Age, a period of the late Neolithic.
- He still used stone tools but owned an innovative and valuable copper axe.
- The skill of extracting and processing metal had recently arrived in Europe from Asia Minor. The advent of copper marked the beginning of the Bronze Age.



Two species of polypore mushrooms were found as his possessions.

One of these, the birch fungus, is known to have anthelmintic properties and was probably used for medicinal purposes.

The other was a type of tinder fungus, which included part of what appeared to be a complex fire-lighting kit.

typical weakness
parasite of dying
beech, alder,
birch, or
hornbeam trees

Fruit bodies appear on the
trunks of over-aged or dead
beech trees; shelf-shaped,
perennial.

grow up to 50 cm in
size and have a zoned,
bulging appearance

Trees are
easily
uprooted by
the wind

In larger shrinkage
cracks and trunk
cracks, the fungus
forms yellowish-white
mycelial flaps, which
partly resemble
chamois leather.

they are very variable in color



can also survive for
years as an endophyte
without symptoms in
healthy wood, and
then, for example,
grow into storm-
induced hairline
cracks in the wood

Fomes fomentarius (tinder fungus)

Host: Hardwood (Red beech, Oak, Birch, Poplar, Maple), softwood (Spruce, Fir)

Fruiting Body: Perennial, frequent common appearance with *F. pinicola*

Rot: Simultaneous white rot



Often with black demarcation lines in the wood



<https://www.pilztag.de/pilze/fomes-fomentarius-echter-zunderschwamm/>

- It is found on standing and fallen hardwoods.
- Its woody upper surface develops grayish zones, and its brown pore surface features tiny round pores.
- When sliced open it is usually composed more of vaguely layered tubes than flesh.



- This large bracket fungus attacks mainly birch but occasionally beech and sycamore.
- The pale leather-brown flesh was used for lighting fires (it burns very slowly); for this reason, it was given the name Tinder Fungus.





<https://www.projectcece.com/catalog/product/9304627/nat-2tm-fungi-brown-white-wmx/>



https://www.zvnder.com/index_eng.html

Piptoporus betulinus (birch polypore)

Host: ("wirtsstet") Birch

Fruiting Body: Annual, July – November

Rot: intense brown rot on stem and crown area



upperside

underside



https://www.naturspektrum.de/db/m_spezies.php?art=piptoporus_betulinus

- Barbers used to 'strop' or sharpen their cut-throat razors on tough, leathery strips cut from the surfaces of these polypores, and so they became known as the Razor Strop Fungus.



https://www.youtube.com/watch?app=desktop&v=pB_n1Qeg2PI

- Agaric acid, found in the fruit body of the fungus, is poisonous to the parasitic whipworm *Trichuris trichura*.
- The fungus was carried by "Ötzi the Iceman" – the 5,300-year-old mummy found in Tyrol, with speculation that the fungus may have been used as a laxative to expel whipworm.



- *Trichuris trichiura* can cause the serious disease Trichuris dysentery syndrome (TDS), with chronic dysentery, anemia, rectal prolapse, and poor growth.

<https://clinicalgate.com/trichuriasis-trichuris-trichiura/>

Armillaria root rot (Hallimasch)

- *Armillaria* species complex
- occurs worldwide
- most common fungus in the forest floor
- *A. mellea* (honey fungus)
- Hardwoods
- problematic in afforestations or clearings or *A. ostoyae* (dark honey fungus)
- in conifers
- especially with waterlogging stress or drought stress
- Acidic sites after defoliation



K. Blumenstein

Also typical: reddish-brown / black rhizomorphic “shoelaces” (mycelium 1-3 mm in diameter) - black on the outside, white on the inside

Rhizomorph *Armillaria ostoyae*

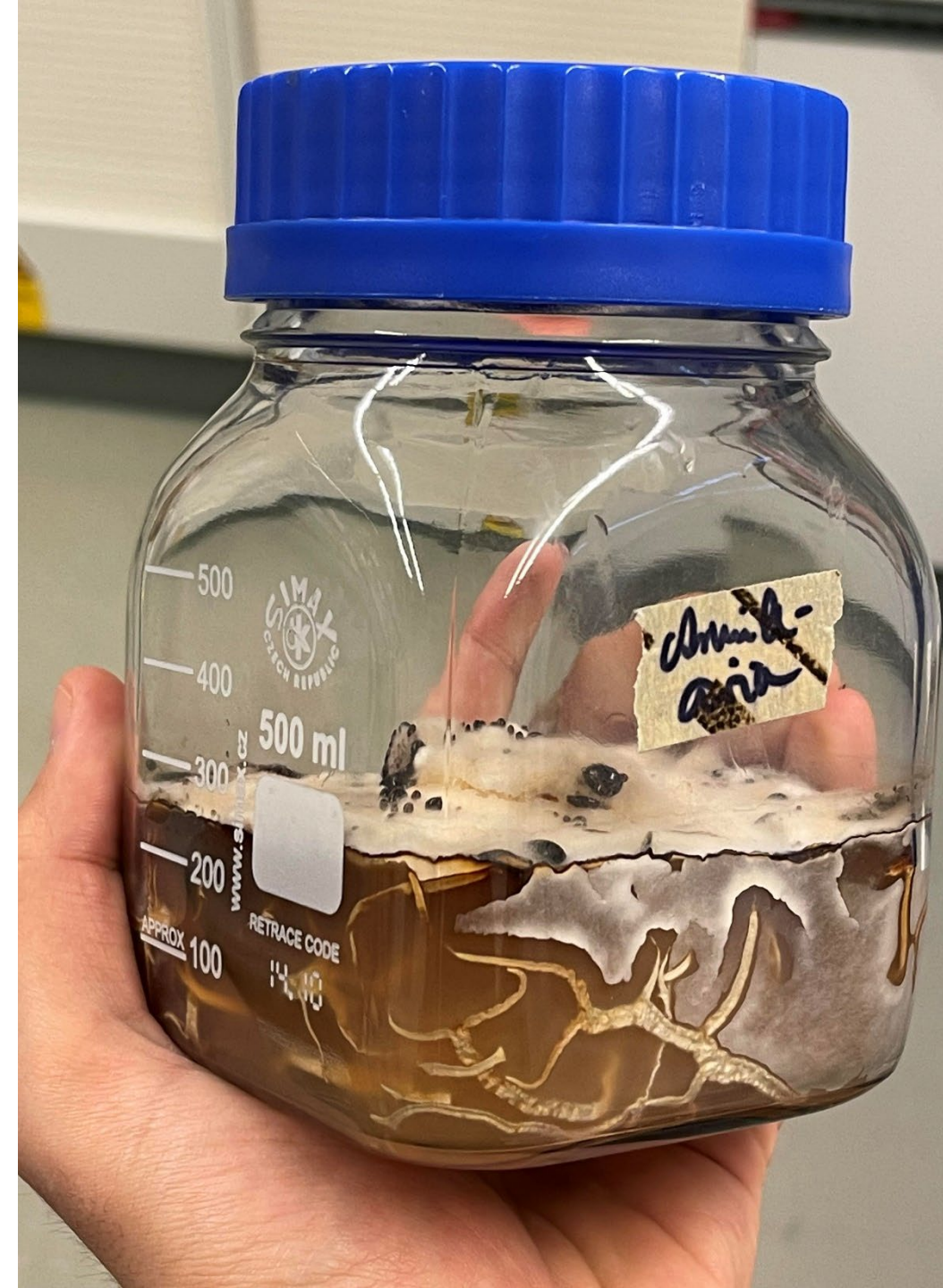


<https://mycotopia.net/topic/55384-honey-fungus-rhizomorphs-for-id/>



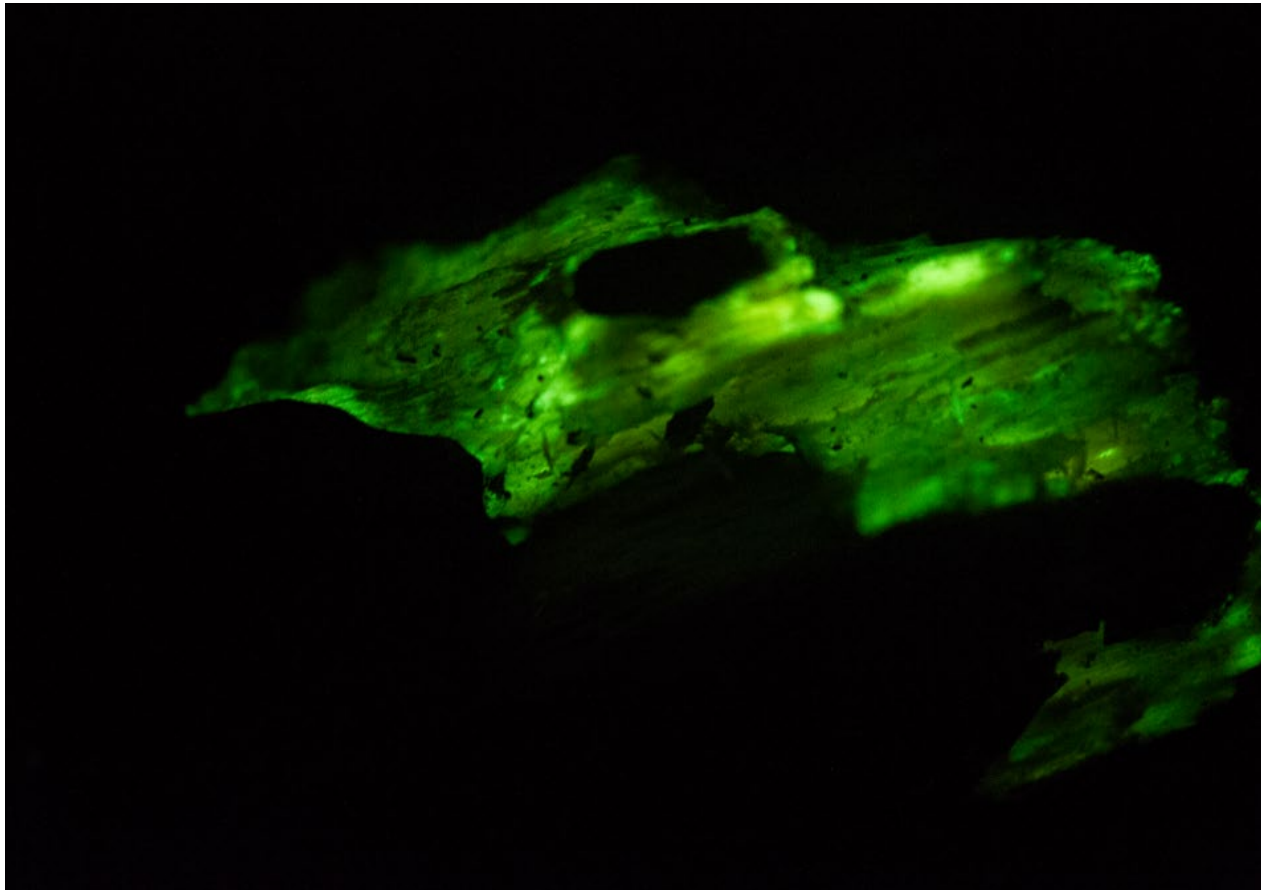
www.distanthillgardens.org <https://flic.kr/p/qgCo7o>

- The word “rhizomorph” literally means “root form.” Rhizomorphs are so named because they resemble plant roots.
- For the fungus, the rhizomorph’s functions include branching out to search for additional food sources and transporting nutrients over long distances.
- Rhizomorphs on fungi can travel farther than individual hyphae can. Some rhizomorphs have hollow centers similar to plant xylem, which allows the fungus to transport larger volumes of water and water-soluble nutrients.

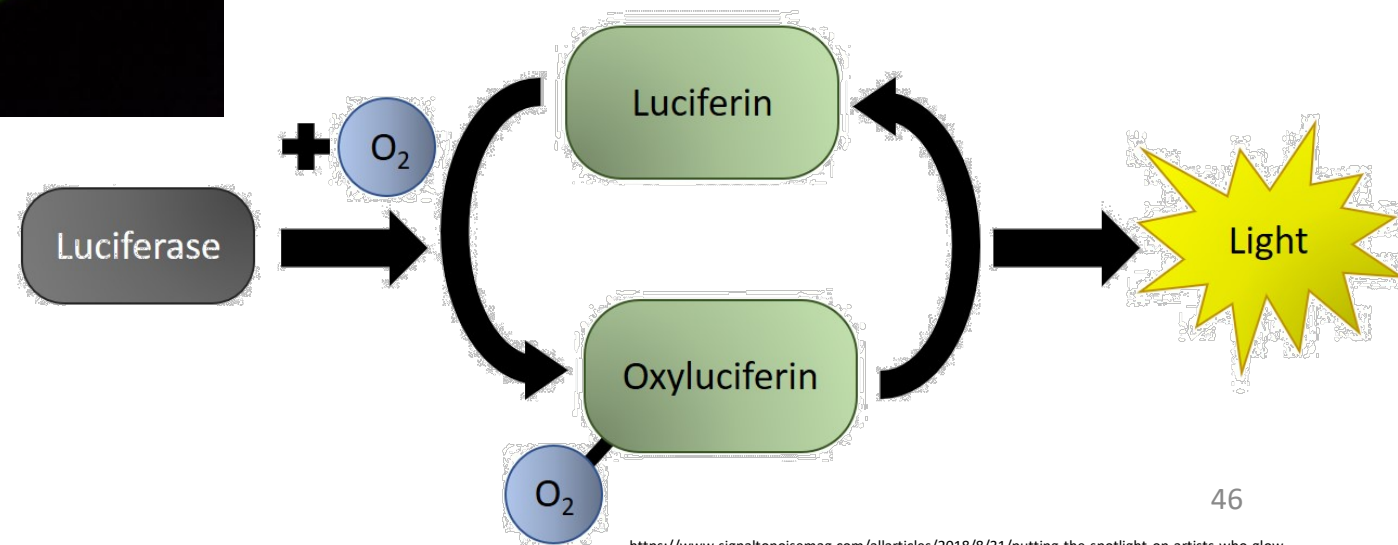


Armillaria mellea





- Bioluminescence may occur in mycelia and fruit bodies or only in mycelia and young rhizomorphs, as in *Armillaria mellea*.
- The fungi use the light to lure insects. Fungi cannot move, disperse the spores, and colonize new areas in the forest. Therefore, they must rely on the wind or animals, such as insects, to carry their spores elsewhere.





By Peter Yeung 11th April 2022

From deep-sea fish to fireflies, dozens of organisms use bioluminescence to help themselves be seen in the natural world. But can we harness them to light our towns and cities?

In a tranquil side room of the Covid-19 vaccination centre in Rambouillet, a small French town around 30 miles (50km) south-west of Paris, a soft blue light emanated from a row of cylindrical tubes. Members of the public who received a vaccine last year were invited to bathe in the glow for a few minutes while they waited in the recovery area.



Japanese universities create glowing tree for non-electric lights

[Salam Groovy Japan Staff](#) — 1 Year Ago

At CES 2022, held in the USA in January, two Japanese national universities: Osaka University and Nara Institute of Science and Technology, showcased their research on **glowing plants**. CES is one of the world's top annual high-tech electronics trade fairs.



<https://2010.igem.org/Team:Cambridge/Tools/Lighting>

We had thought about bacteria being used for emergency lighting, and our advisor Fernan printed a fire exit sign, which was placed over a plate containing one of our strains of *E. coli*. In a real system, we imagine using anhydrobiosis to create bacteria 'in hibernation,' which could be activated when needed.

Schizophyllum commune



Schizophyllum commune (common split-leaved plant)



Host: On deciduous wood (especially Beech, Linden, Alder, Poplar, and Prunus species), softwood (Larch, Spruce, Fir)

Fruiting Body: Annual

Rot: White rot

Classic secondary pest and saprophyte after Sunburn and bark-damaged

Underside with typical longitudinally split lamellae



<https://en.wikipedia.org/wiki/Schizophyllum>

- The splits in the gills of *Schizophyllum commune* close over the fertile surfaces as the fruitbody shrivels during prolonged dry weather, rehydrating when moistened by rain; then the splits reopen, the spore-producing surfaces are exposed to the air, and spores are released.
- Split Gills can survive several such cycles of dehydration and rehydration, a facility that enables these fungi to live on every continent on Earth except Antarctica.
- Often, when fungi appear similar but occur on widely separated continents, DNA analysis shows their genetic separation is so great that they should be - classified as distinct species. Thanks to the work of John Raper and colleagues at Harvard University over two decades from the 1950s to the 1970s, we know that *Schizophyllum commune* is one species worldwide.



Root rot

Heterobasidion annosum
sensu lato





https://westernforestry.org/wp-content/uploads/2016/06_Kristen-Chadwick.pdf

Spruce stand (*Picea abies*)



<https://www.cabi.org/isc/datasheet/27042>Kari Korhonen

Pine stand (*Pinus sylvestris*)

Genus: *Heterobasidion*

- *H. annosum* –
Species complex: *H. annosum* sensu lato (s.l.)

necrotrophic
pathogens and
saprotrophs

Genus: *Heterobasidion*

- *H. annosum* –
Species complex: *H. annosum* sensu lato (s.l.)

necrotrophic
pathogens and
saprotrophs

Most harmful pathogens of
coniferous trees

Heterobasidion annosum sensu lato species complex

Pine (*Pinus* spp.),
Douglas fir



***Heterobasidion
annosum* sensu
stricto (s.s.)**

Fir (*Abies alba*)



***Heterobasidion
abietinum***

Spruce (*Picea abies*)



***Heterobasidion
parviporum***

Juniper (*Juniperus* spp.),
Cedrus (*Calocedrus decurrens*),
Pine



***Heterobasidion
irregulare***

Fir,
Giant Sequoia
(*Sequoia* sp.),
Pine



***Heterobasidion
occidentale***

Eurasia

North America



K. Blumenstein



Kari Korhonen

<https://www.cabi.org/isc/datasheet/27042>Kari Korhonen

Division: **Basidiomycota**

Heterobasidion annosum

(Fr.) Bref.

Root Rot Fungus



Kari Korhonen

<https://www.cabi.org/isc/datasheet/27042>Kari Korhonen



wallpapers-all.com

Heterobasidion annosum (Fr.) Bref.



GJ Langer

Epidemiology - Infection

1) Primary infection:

- Basidiospores are transmitted through the air, landing on freshly exposed surfaces



Epidemiology - Infection



1) Primary infection:

- Basidiospores are transmitted through the air, landing on freshly exposed surfaces

2) Secondary infection:

- vegetative growth through mycelium or root contact
- Mycelium penetrates the trunk and grows upwards ($< 0.5\text{m} / \text{year}$)
- Colonization down into the root system ($< 20\text{cm} / \text{month}$)

Epidemiology - Infection



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Infestation depends on various site factors:

- Age
- Soil type
- Site history
- Forest management

Symptoms



White rot



Red rot



**Crown reduction
Chlorosis
Reduced growth**



Wind throw



Gap in pine forest



Resin flow

Terhonen, E., Langer, G. J., Bußkamp, J., Răscuțoi, D. R., and Blumenstein, K. (2019). Low water availability increases necrosis in *Picea abies* after artificial inoculation with fungal root rot pathogens *Heterobasidion parviporum* and *Heterobasidion annosum*. *Forests* 10, 55. doi:10.3390/f10010055.

Weakened trees – higher susceptibility to bark beetles!



<https://schwarzwaldnatur.blogspot.com/2009/09/schutzgebiete-bannwald-hoher-ochsenkopf.html>



Prevention of spread

→ Adjustment of forestry practices

- In Germany: Thinning in winter during frost or in spring and early summer (hardly any spores in the air)
- Control of imported wood for infections



<https://www.nuhn.de/index.php>

Preventive measures to prevent new infections.

- More than half of the trees can be killed before any external symptoms
- Take 1 to 3 year to become visible

Finland is the first country in the world to train dogs to sniff out the Heterobasidion fungus in spruce and rust fungus in pine.



@Sanna Vinblad / Lapland University of Applied Sciences and UPM