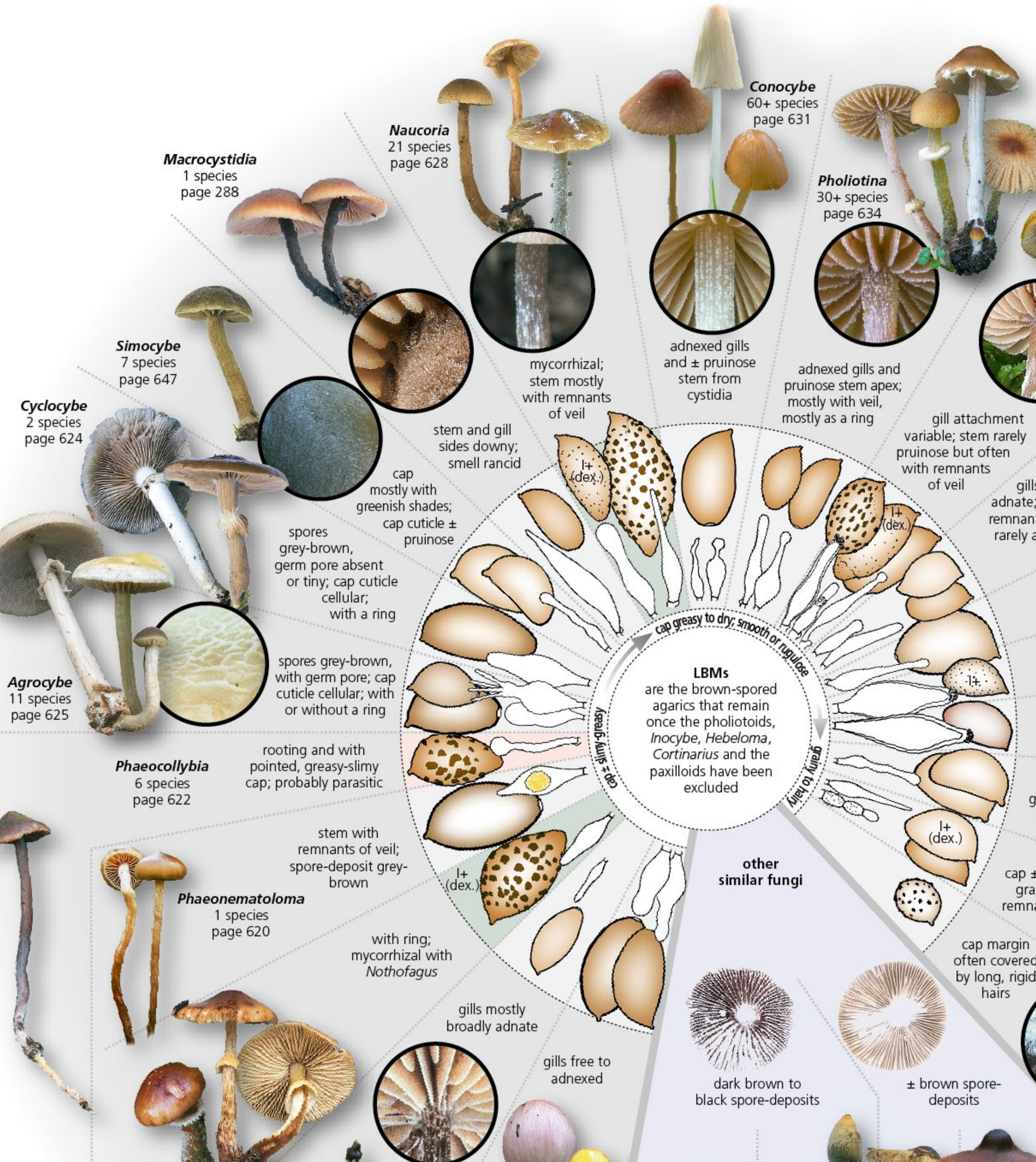
Fungi of Temperate Europe

The wheels

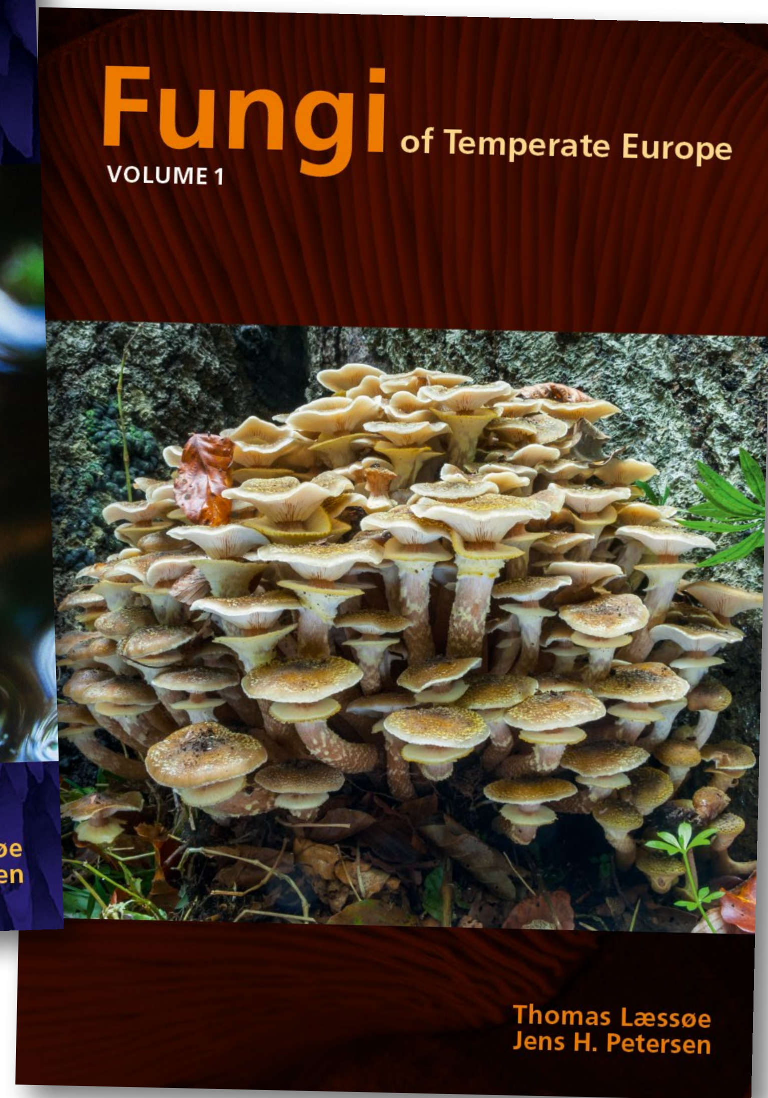
Thomas Læssøe & Jens H. Petersen



Fungi of Temperate Europe is one of the most comprehensive mycological guides ever published. Featuring more than 7,000 photographs, this lavish two-volume set treats more than 2,800 species of fungi across the region.

Including agarics, boletes, chanterelles and morels but also more obscure groups such as cyphelloids, cup fungi, pyrenomycetous fungi and hysterioids, this guide takes an unprecedentedly broad approach to communicating fungal diversity. All species are illustrated with one or more photographs and information is given on morphology, ecology and distribution within temperate Europe. Furthermore, 1,500+ species are discussed as potential look-alikes. The books are divided into eighty "form groups," each starting with an innovative identification wheel with guiding photos, distinguishing characteristics and drawings of essential microscopic features. Poisonous and edible species are colour coded within the text.

Revealing the world of fungi in all its splendour, Fungi of Temperate Europe is a must-have resource for any amateur or professional mycologist.



To distribute the identification wheels as far as possible, we have created this digital version for use on PC, tablet and smartphone. The wheels are linked so you may jump forward from the table of contents and the main wheels and back again with a home button.

The digital wheels can be downloaded from the MycoKey website (www.mycokey.com). They may be printed for personal use and for education, but must not be distributed commercially.

Thomas Læssøe og Jens H. Petersen

Contents

Blue text are links to the wheels.

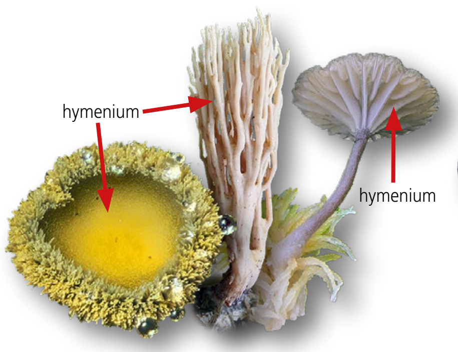
Form groups and fungal wheels

The fungi that are included in the two volumes of this publication have been organized into groups of morphologically similar fungi, which we have called 'form groups'. With some experience, these groups can be recognized with the naked eye or with a hand lens. It is important to remember that form groups do not necessarily reflect natural relationships, since morphology only reflects such relationships to a certain degree. For example, fungi with polypore morphology have evolved multiple times and, as a result, many of the taxa concerned are not closely related – even though they may look similar. The section on polypores in this book therefore covers all the species with polypore morphology, regardless of their current classification.

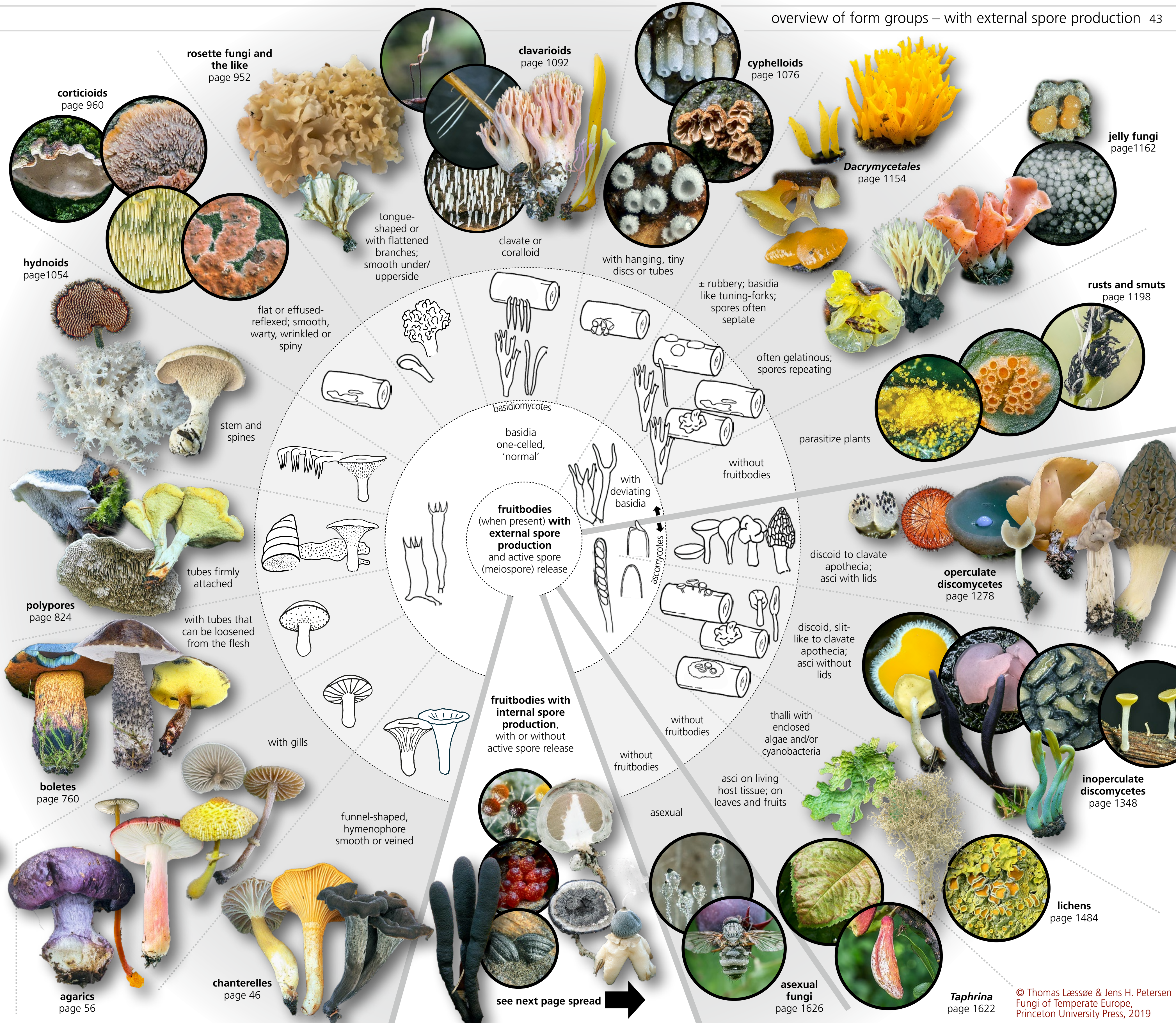
There is one major exception to this general rule. We have divided the fungi, irrespective of their macroscopic appearance, into the two major phylogenetic groups: the *Basidiomycota* and the *Ascomycota*. At the end of Volume 2, we have also included sections on asexual fungi, and organisms that are not fungi but belong in other kingdoms but resemble true fungi, *e.g.* the slime moulds.

The fungal wheels are the key feature of this publication. We have adopted a highly pragmatic approach when preparing these wheels, so that, for example, even if you find yourself looking at the wheel that covers cyphelloids (*Basidiomycota*) (p. 1076), you will find cross-references to similar discoid fungi in the *Ascomycota* (p. 1372). For this reason, prior knowledge of fungal systematics is not a prerequisite.

The wheels on this and the following page spread are organized based on how the sexual spores are produced. In order



Fruitbodies with external spore production on an exposed hymenium, see also page 31.

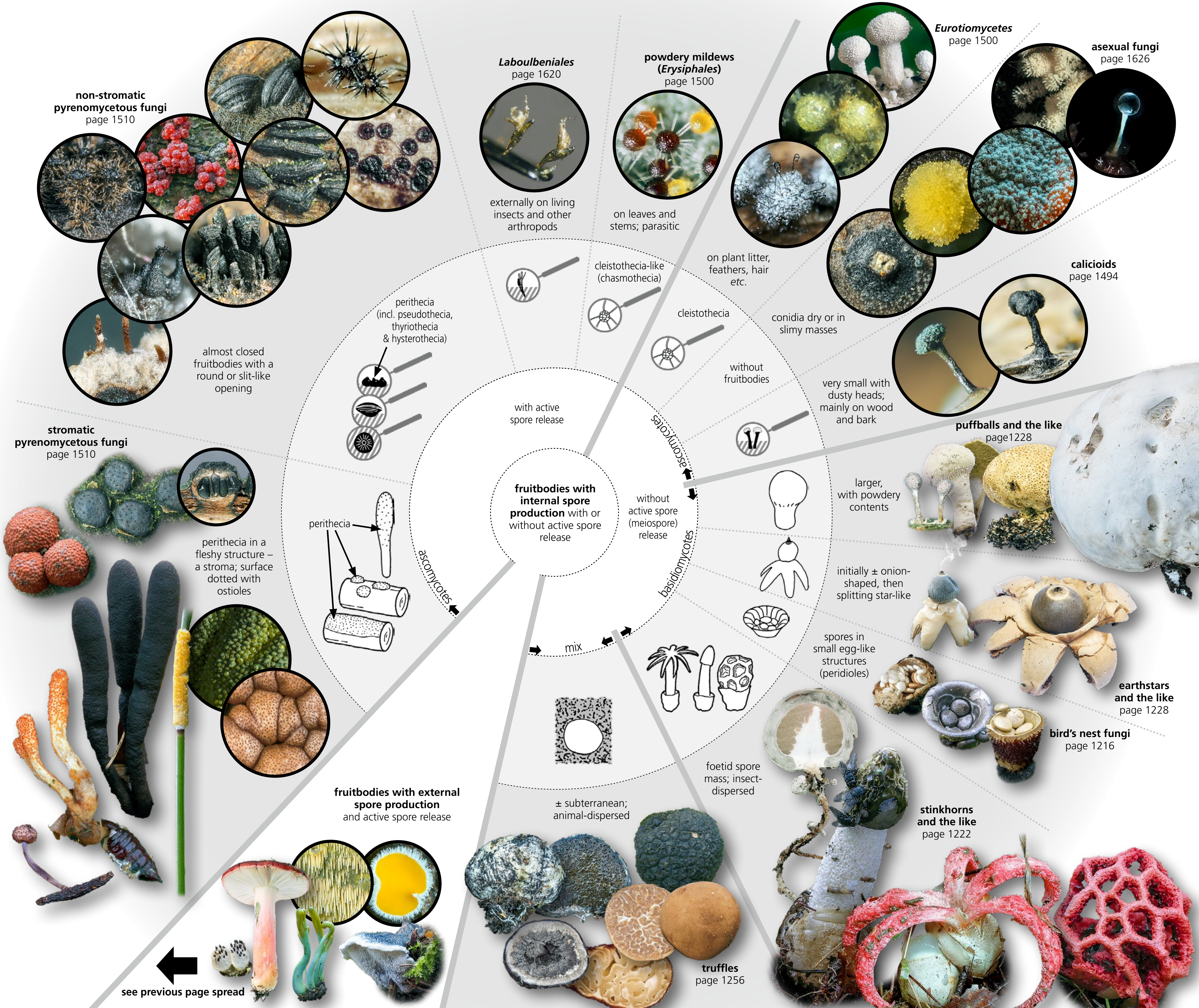


to decide which wheel to use, you will first have to determine whether your chosen fungus produces spores from an external hymenium (see p. 31 and the illustration p. 42 bottom left). The hymenium consists of a palisade of basidia or asci, and typically forms a smooth surface on the fruitbody. Fruitbodies with internal spore production do not display such a surface. Instead, you may find small openings (ostioles), through which the spores can be ejected. Form groups with external production and active dispersal of the sexual spores (meiospores) from hymenia are found on the previous page spread, and groups with internal spore production are covered on this page spread.

On this page spread, the groups with spores that are actively released are shown at the upper/left side; the groups with fruitbodies that have passive spore dispersal, or have a powdery or slimy inner spore mass, are represented in the lower/right side of the wheel. For passive spore dispersal to take place an external force is often required, *e.g.* rain drops or animal activity.

The wheels here and throughout this publication can be used in various ways. By checking the images in the outer 'rim', a quick overview can be obtained of the variation in the fungal groups covered. Images in the pale blue sections (see, *e.g.*, the wheel on page 46) represent fungi that in some way recall species from the form group covered by the wheel, and which are treated in other wheels in this publication; the relevant page number is given for ease of cross-referencing. The inner part of the wheel shows other features that could be considered, particularly microscopic characters such as spore morphology (see, *e.g.*, the wheel on page 60 and 176).

We recognize that the wheel approach to fungal identification will never reach the same level of accuracy as a traditional analytical key. The distinguishing features of some fungi are not always clear-cut, and several wheels and species accounts may need to be consulted in order to reach a satisfactory conclusion. However, we hope that the approach taken in this publication will be easier to use than trying to follow the often highly technical keys found in other identification guides.



Chanterelles and the like

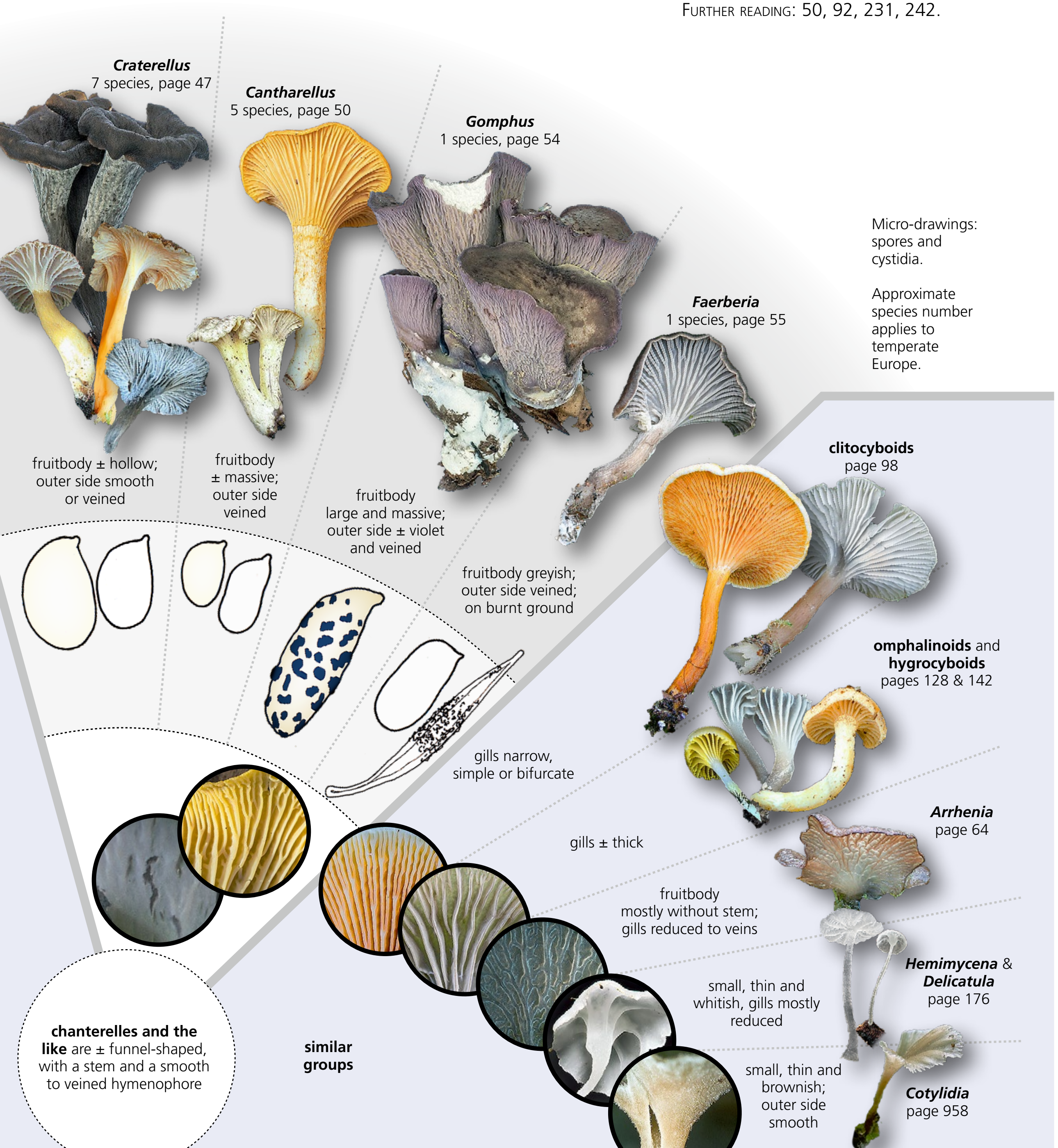
The form group have rather fleshy fruitbodies with a ± central stem and a deeply decurrent hymenophore that may be completely smooth or consist of ± branched veins to wrinkles. The fruitbodies can be massive or hollow.

The core group is *Craterellus* and *Cantharellus*. These genera belong in *Cantharellales* and both form ectomycorrhiza.

Gomphus clavatus, which belongs in *Gomphales*, also forms ectomycorrhiza, while *Faerberia carbonaria*, which is situated in *Polyporales*, is a decomposer.

Similar groups:
– clitocyboids have similar shapes to the chanterelles, but have typical gills that may be forked (page 98).
– some omphalinoids have a veined hymenophore, but are smaller with reduced stems (page 128).
– funnel-shaped hygrocyboids and omphalinoids have decurrent gills (pages 128 & 142).
– some mycenas (*e.g. Hemimycena*) may look similar, but are small, fragile and white (page 176).

Further reading: 50, 92, 231, 242.



Chanterelles within the genus ***Craterellus*** have a smooth or veined outer side where the hymenium is situated. They also have a ± hollow stem.

●● ***Craterellus cornucopioides*** is a thin-fleshed, grey-black to brown, rarely yellow-brown, trumpet-shaped fungus with an undulating margin and with an almost smooth, grey hymenium, which is strongly decurrent. The stem is hollow; the cap surface is felty and the smell is very pleasant. The smooth, hyaline spores measure (9–)10–13.5(–16) × (5.5–)6.5–8.5(–9.2) µm. Forms ectomycorrhiza with mostly *Fagus* and *Picea* on better, typically ± clay-rich, calcareous soils.

Craterellus cinereus ▷▷ has obvious wrinkles. The two species occasionally occur close together. A yellowish form has been separated as *C. konradii* (lower image).

Widespread and locally common, becoming scarcer towards the north; mostly September–October.

Jan Vesterholt

Agarics

The gilled mushrooms comprise a very large group of macrofungi, with more than 3,000 species in temperate Europe. They are characterized by having gills under a cap, always held in the vertical postion. Most species also have a stem. In the pleurotoid agarics the stem is reduced or absent.

Spore colour

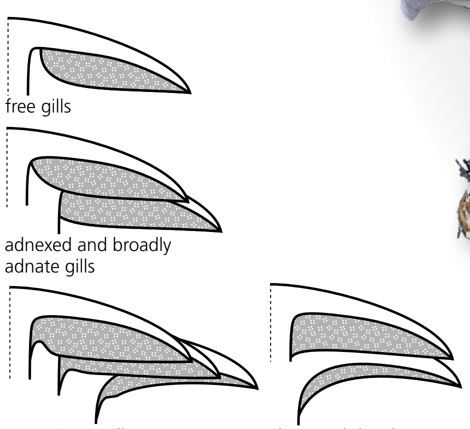
The colour of spore-deposits is a key character for dividing the gilled mushrooms into manageable groups: white, cream to yellow (this page spread) or brownish, rose-brown to black (next page spread). In addition, a few species have green or lilac spore-deposits (also next page spread).

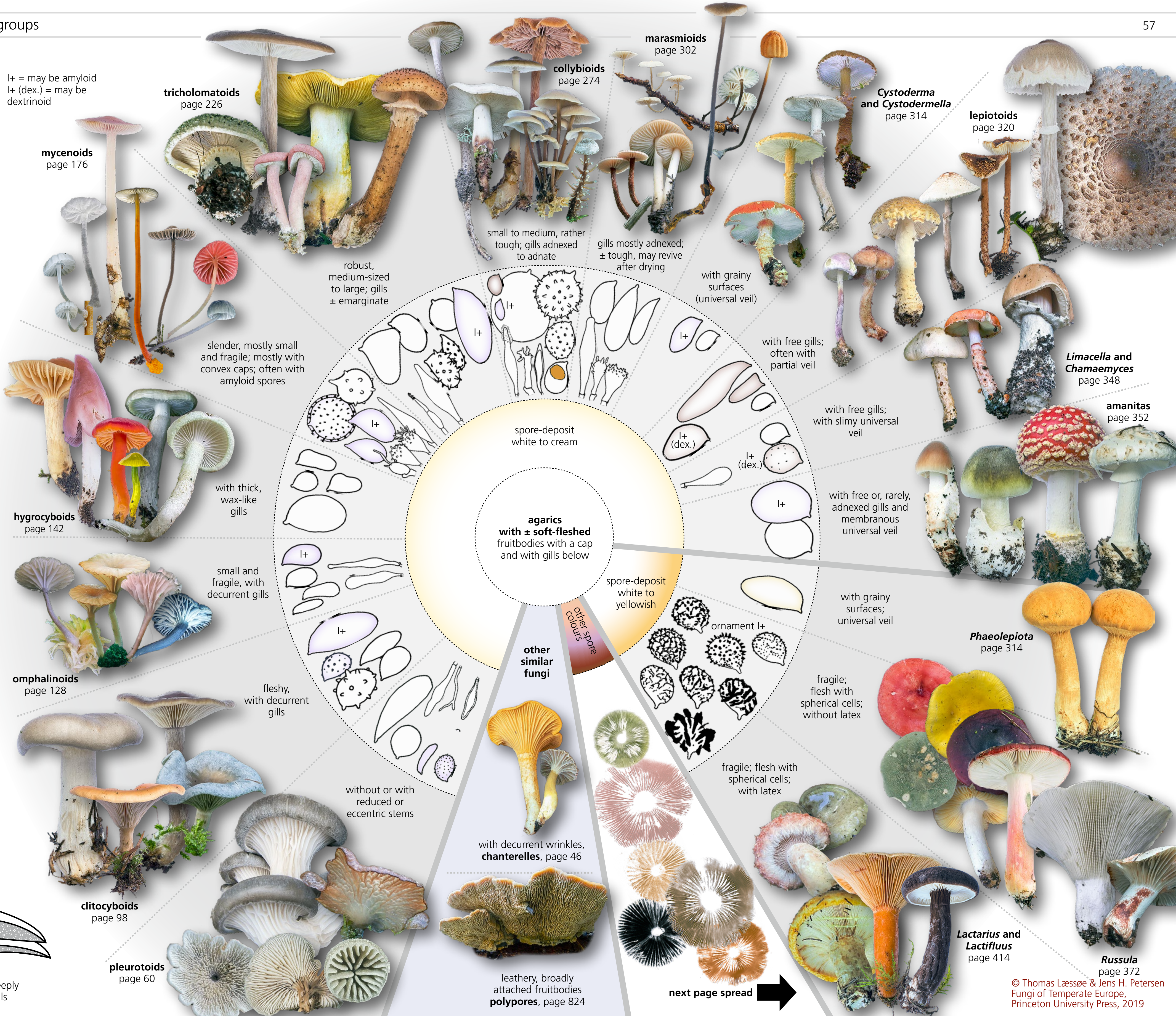
Veil

In some agarics the gills develop freely – a naked development. Others have a protecting tissue over the young gills – a partial veil. Some have the entire fruitbody covered in an universal veil. *E.g. Amanita phalloides* has a membranous version of both veil types: the partial veil is seen as a ring on the stem at maturity, while the universal veil is seen as a volva at the stem base. In *Cortinarius* the two veil types can be thread-like and in others, *e.g. Gomphidius,* they are present as slimy layers.

Gill attachment

The way the gills attach to the stem is an important character for separating species and genera. The gills may be free (not touching the stem), adnexed, adnate, emarginate or decurrent.





Microscopical characters

Many species of agarics have cystidia on the stem (caulocystidia), cap surface (pileocystidia) or on the gills. The gill cystidia are divided into those in the hymenium (pleurocystidia) and those on the edges (cheilocystidia). The cystidia are very important in species identification. It it advisable to use a dissection microscope when making preparations, to ensure that the appropriate part of the gill is studied.

Agarics have a huge range of spore types: smooth, angular, to spiny, thin- to thick- or double-walled, with or without germ pore. Some spores stain ± blue with Melzer's reagent (termed amyloid or I+). When studying microscopical characters always check for amyloidity and surface ornaments (use oil immersion).

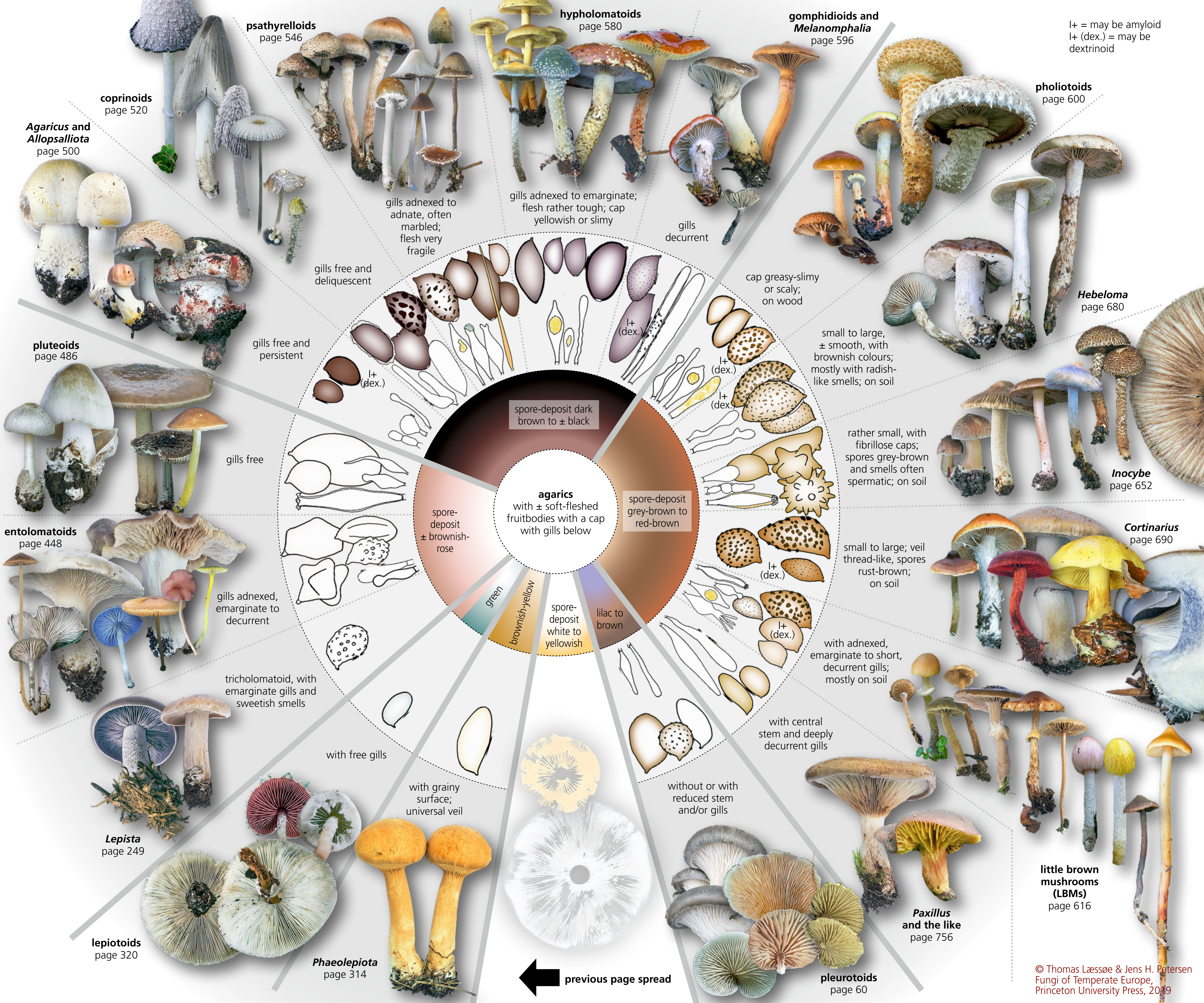
Relationships

The agarics constitute a 'form group' – an artifical assemblage. The biggest monophyletic groups of agarics are the *Agaricales*, the *Russulales* and the *Hymenochaetales* each of which include many species that are not agarics, e.g. corticioids, clavarioids, puffballs and polypores.

OTHER SIMILAR FUNGI:

– chantarelles do not have proper gills but, instead, sinuose, branching veins or wrinkles (page 46).

– certain polypores have gill-like hymenophores, but these structures are normally very tough (page 824).



Pleurotoids

The pleurotoid agarics are either fan- or tongue-shaped and lack or have an excentric to lateral stem. Some forms are attached on the backside, with the gills forming a radiating pattern. Some have the gills reduced to veins or wrinkles, or even to a ± smooth hymenophore. Species with a smooth hymenophore and no stem are treated under the cyphelloid fungi (page 1076).

Most species in this group are decomposers and the majority grow on wood, even though some are also nematophagous. A few occur on herbaceous stems: *Gloiocephala*, *Campanella*, and some of the *Hohenbuehelia* species, one species of *Lentinellus*, one *Clitopilus*, several *Entoloma*, some *Deconica* and a few *Crepidotus* species.

Pleurotoid agarics have different spore-deposit colours. The majority are white- to cream-spored, but a smaller group is rose- or brown-spored and *Pleurotus ostreatus* has a greyish-violet spore-deposit. The different spore colours reflects the fact that the species concerned have completely different phylogenies. The spore colour is used in the division of the groups in the wheel.

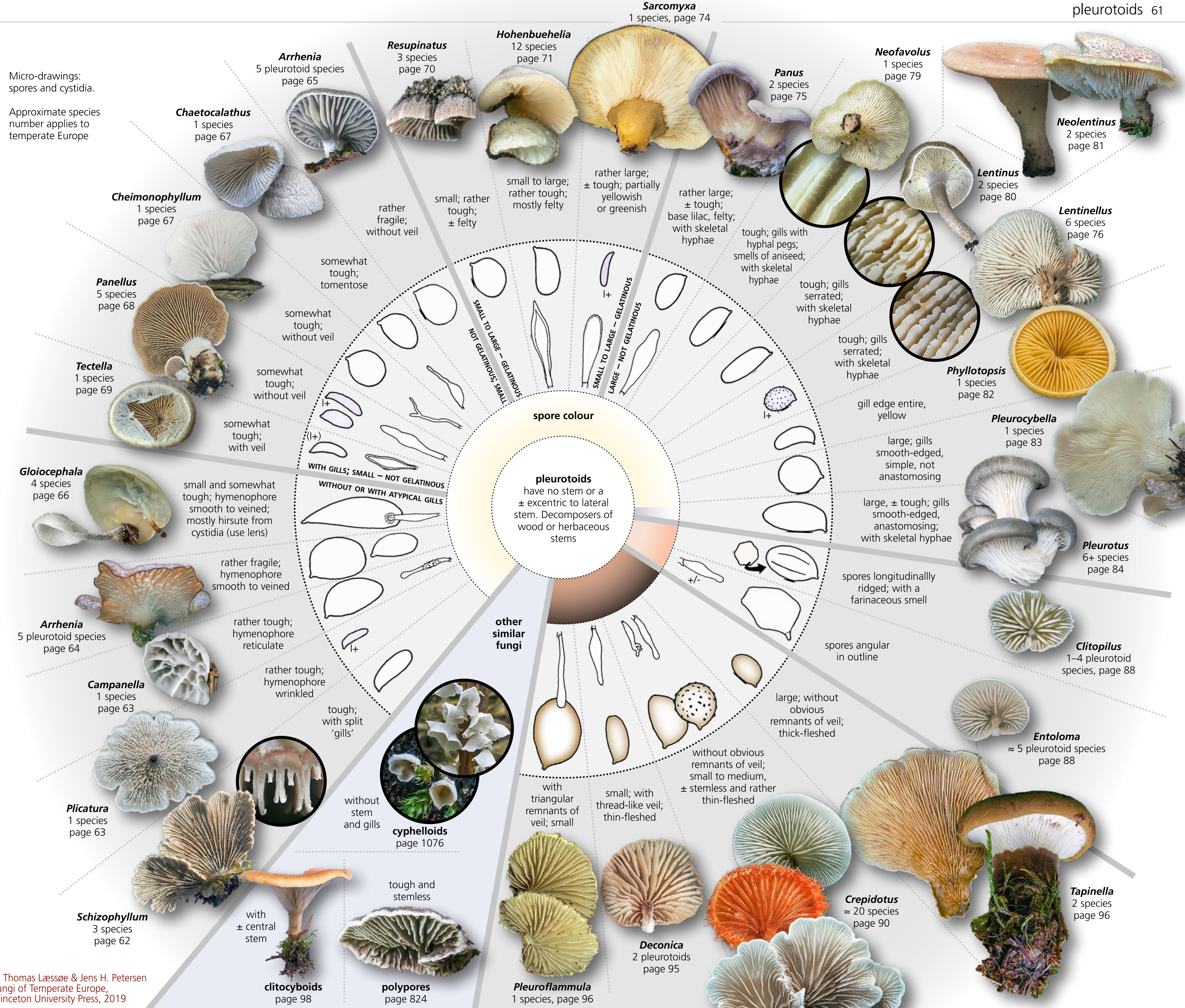
Some species of pleurotoids are remarkably tough, *e.g. Panus* and *Neofavolus* and also older fruitbodies of *Lentinellus* and *Pleurotus*. Others, *e.g. Schizophyllum*, *Hohenbuehelia* and *Sarcomyxa*, have gelatinous or rubbery flesh.

Other similar fungi:

– the cyphelloid fungi have small fruitbodies without gills and no or hardly any stem. They are typically attached on the upperside of the fruitbody (page 1076).

– the clitocyboids have central stems, but may recall pleurotoids (page 98).

Further reading: 11, 65, 66, 156, 181, 203, 223, 224, 245, 295.



Clitocyboids

Clitocyboid agarics have short to deeply decurrent gills. The cap is umbonate, applanate or funnel-shaped and the flesh is mostly obviously fibrillose but not very tough. Some species form small fruitbodies, but most are medium-sized to very large. Most clitocyboids have white to cream spore-deposits, but in some species belonging to the genera *Clitocybe* and *Paralepista* they are clay-pink.

Almost all clitocyboids are decomposers of litter or soil. Exceptions include *Ossicaulis* and *Omphalotus* that are lignicolous. *Hygrophoropsis* and *Aphroditeola* may also grow on remnants of wood. *Catathelasma* forms ectomycorrhiza with conifers.

The generic division of the clitocyboid agarics has gone through large changes, with many species, previously accepted in *Leucopaxillus* and *Clitocybe,* now being assigned to a number of new genera.

Other similar fungi:

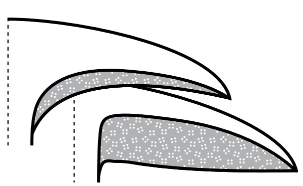
– omphalinoids may look rather similar, but are mostly more fragile and smaller. Some have a biotrophic association with mosses, *etc.*, others are decomposers (page 128).

– pleurotoids likewise have deeply decurrent gills but have excentric stems. Many of these (*e.g. Neolentinus* and *Lentinellus*) have distinctly tough flesh (page 60).

– entolomatoids may be shaped like clitocyboids, but have brownish-rose, verrucose, striate or angular spores (page 448).

– *Paxillus* and others are shaped like clitocyboids but have brownish spore-deposits (page 756).

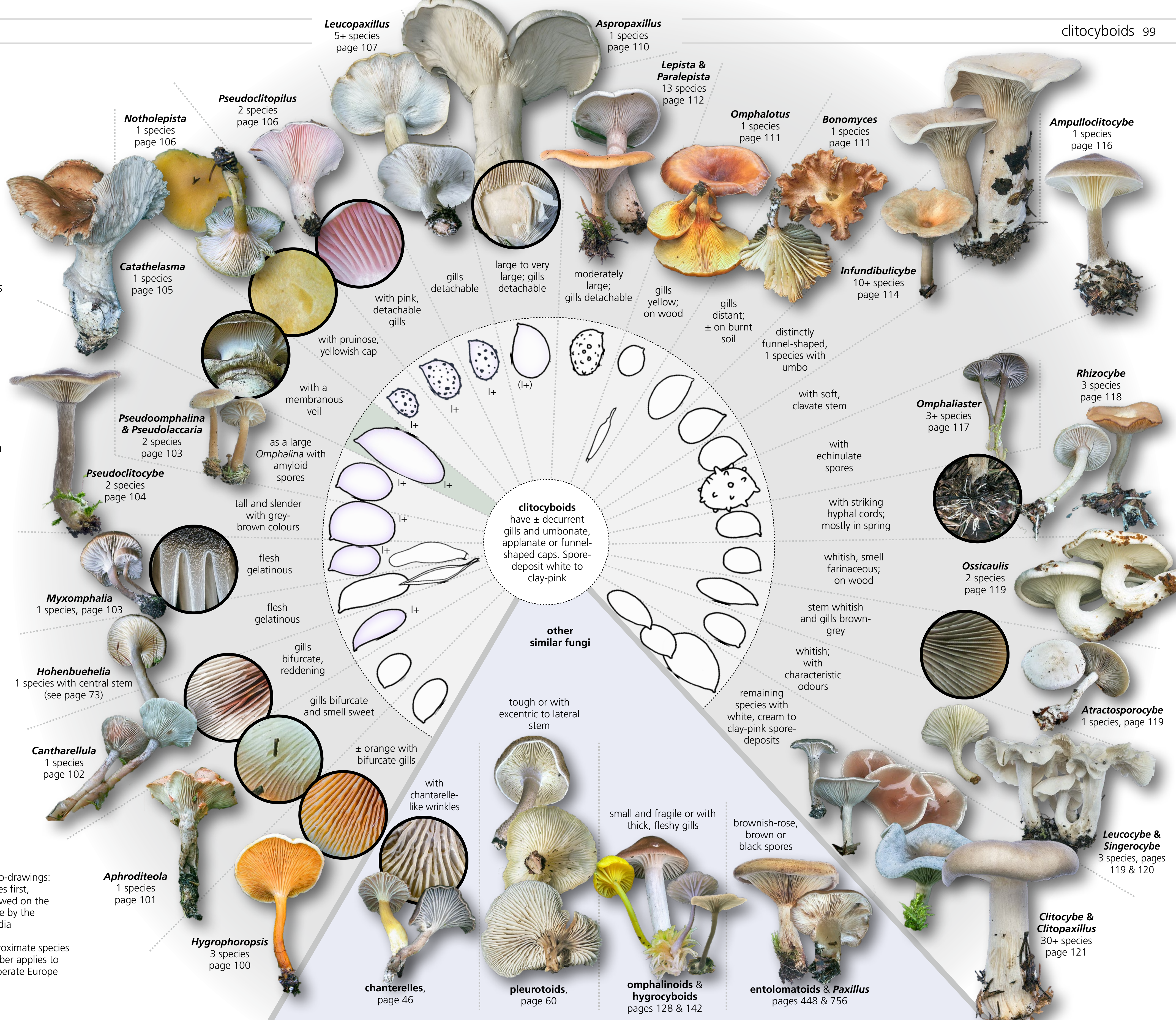
Litteratur: 8, 9, 10, 27, 110, 156, 174, 181, 183, 340, 344.



deep and short decurrent gills

Micro-drawings: spores first, followed on the inside by the cystidia

Approximate species number applies to temperate Europe



Omphalinoids

The omphalinoid fungi are a loosely defined form group of white-spored agarics with relatively small, mostly dry, somewhat fragile and elegant fruitbodies and rather deeply decurrent gills. Although the name suggests that all are umbilicate, this is far from the case. They can also be convex, umbonate or applanate without an umbilicus.

Some omphalinoid fungi are biotrophic, either as lichenized with algae or as parasites on mosses (left side of the wheel). Others are decomposers (saprotrophs) of litter, herbs or wood (right side of the wheel).

Other similar fungi:

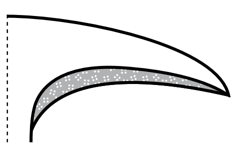
– some hygrocyboids (*Hygrocybe* and others) with decurrent gills look distinctly omphalinoid. However, the hygrocyboid fungi have, in general, very slender basidia (6–9 times as long as wide) and live mostly as biotrophs amongst phanerogams (page 142).

– some mycenas with decurrent gills are also omphalinoid. Many mycenas can be separataed by their amyloid spores, but *e.g. Phloeomana speirea* and related species and the genus *Hemimycena* are inamyloid (page 176).

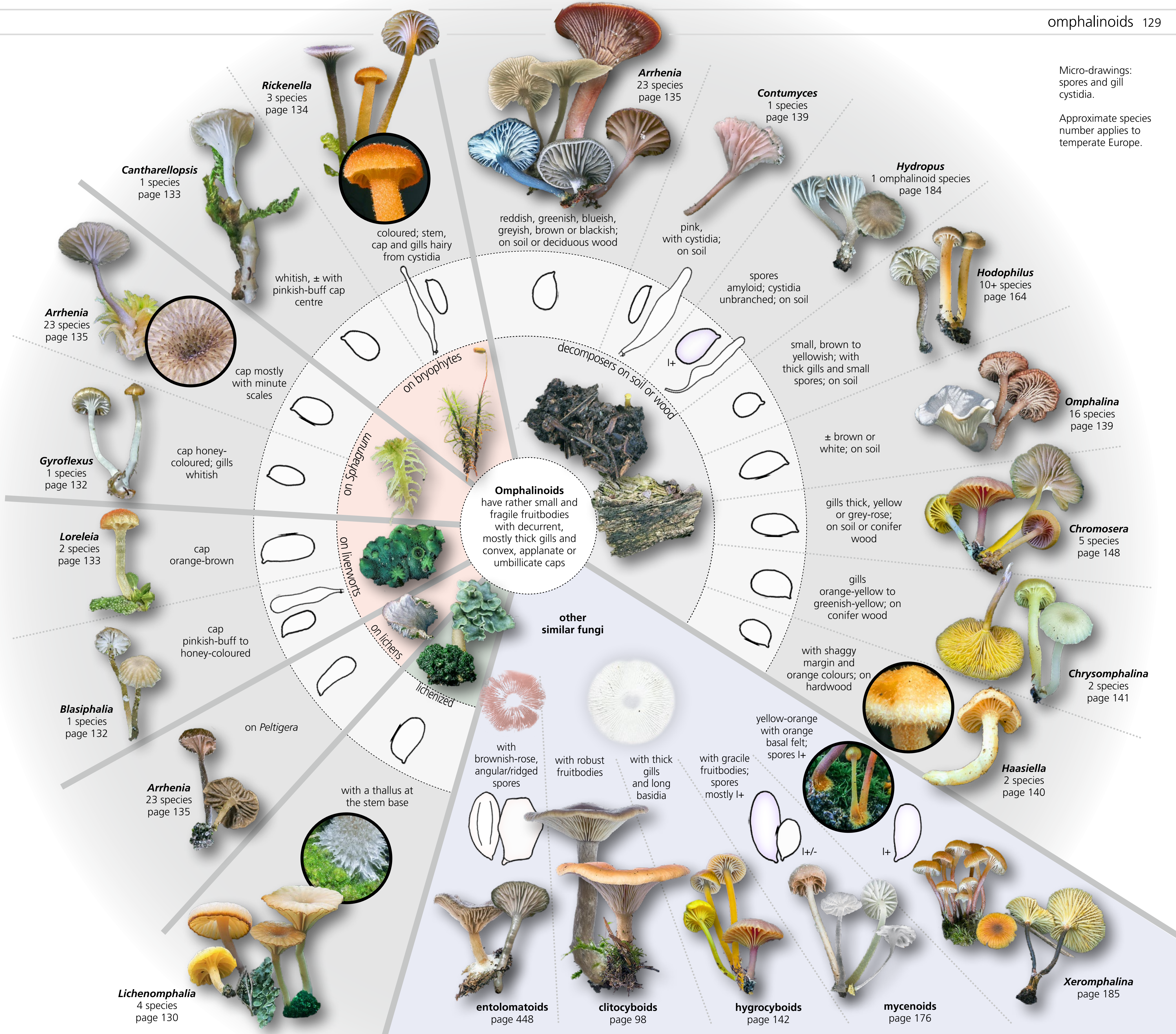
– the clitocyboids have predominantly decurrent gills, but are mostly larger and tougher than the omphalinoids (page 98).

– some species of entolomatoids also look similar, but these have brownish rose spore-deposits, and the spores are ridged or angular (page 448).

Litteratur: 156, 181, 262.



deeply decurrent gills



Micro-drawings: spores and gill cystidia.

Approximate species number applies to temperate Europe.

Hygrocyboids

The hygrocyboid agarics (waxcaps and others) are recognized by their thick, wax-like and mostly rather distant gills, and many species have very vivid colours. Microscopically, most hygrocyboids have unusually long and slender basidia, typically 6–9 times as long as wide. The spore-deposits are whitish and the spores smooth and inamyloid; as a general rule cystidia are lacking.

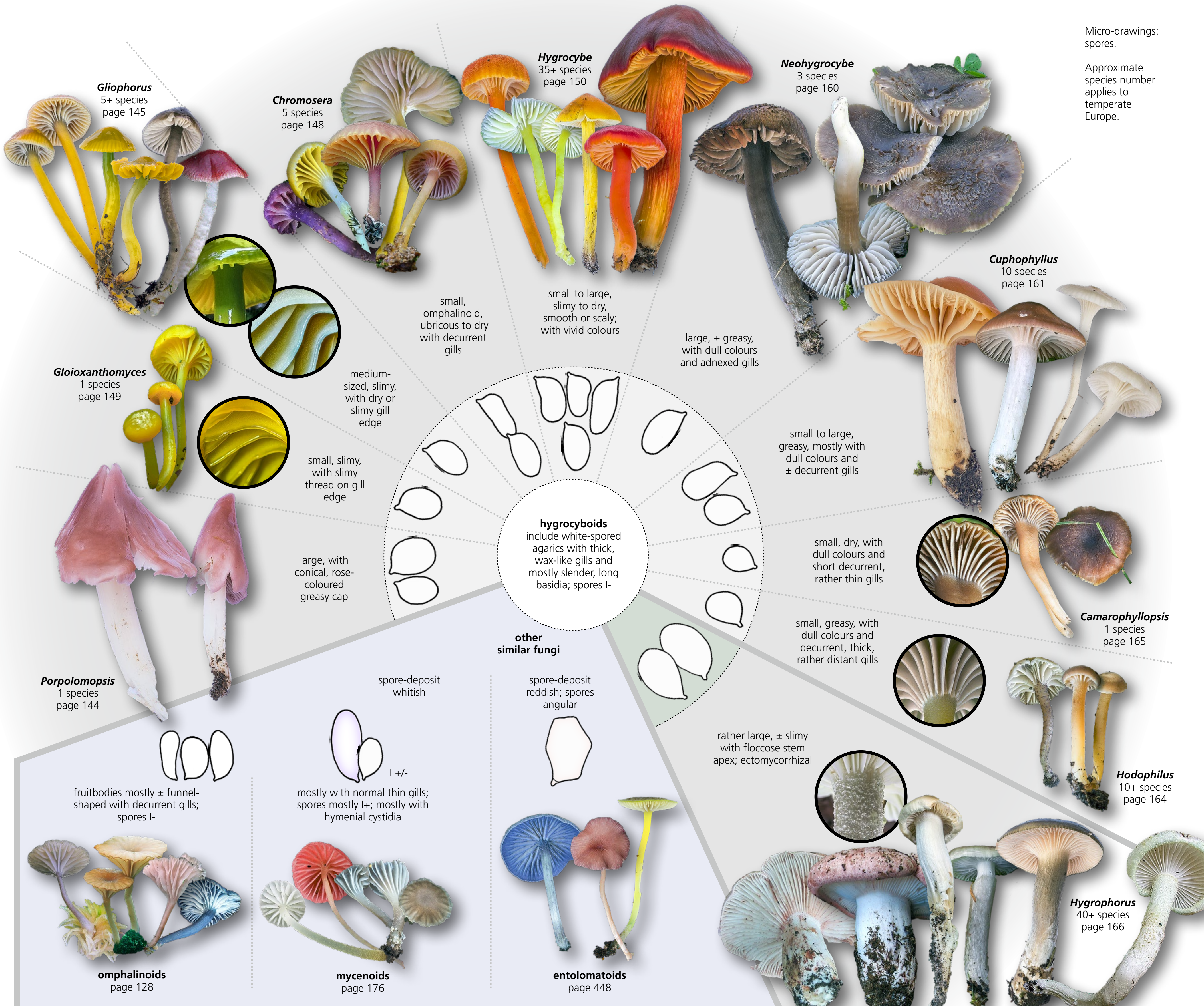
Most hygrocyboids are thought to be biotrophic, with a poorly understood symbiosis with herbs. Using DNA-analysis techniques, living hyphae have been detected inside tissues and seeds of *Plantago*. Species of *Hygrophorus* are also proven to be biotrotrophic, but they form ectomycorrhiza with a number of woody partners. One species (*Hygrophorus exiguus* ×) appears to be associated with *Tricholoma* mycorrhiza.

Most hygrocyboid agarics have very demanding habitat requirements. They are particularly sensitive to fertilizers and many favour habitats with a long continuity. The hygrocyboids share the same habitats and have similar preferences to a number of clavarioids, entolomatoids and earthtongues; they are all good indicators of sites of special nature conservation value.

In most of Europe the typical habitat for hygrocyboids, except *Hygrophorus* and *Hodophilus*, is old, unfertilized grassland – a habitat that has declined dramatically over the past 50 years. In other parts of the world, the hygrocyboid agarics are predominantly to be found in forests with long continuity. Species of *Hodophilus* tend to prefer thorny thickets on clay soils.

Other similar fungi:
– omphalinoids may also have thick, fleshy gills; many are parasites on mosses or are lichenized, but some are saprotrophs (page 128).
– mycenoids generally have 'typical' gills and most have cystidia and amyloid spores. They are all believed to be saprotrophs (page 176).
– entolomatoids may be colourful, but have angular, pinkish spores (page 448).

Litteratur: 1, 2, 3, 43, 57, 156, 172, 178, 183.



Mycenoids

Mycenoids are small, rather fragile or somewhat tough agarics with white spore-deposits. Most species have a bell-shaped or convex cap, but may become applanate or even somewhat funnel-shaped with age. The gill attachment comes in all forms, except completely free. Smell and surface features – dry versus slimy *etc.* – are important characters. In the field it is important to note whether the fruitbodies have a distinctive odour, *e.g.* radish-like, like iodoform or nitrous, and whether parts of the fruitbody are slimy.

The mycenoid fungi often have smooth, amyloid spores. Many species have characteristic cystidia in the hymenium or in other places.

The mycenoid fungi are mainly decomposers and often occur on leaf or needle debris, on dead wood or on the bark of living trees. A few species (*e.g. Mycena galopus*, page 205) may form mycorrhiza-like associations with ericaceous plants.

Mycena is the most speciose mycenoid genus in temperate Europe, and the next is *Hemimycena*. The latter has inamyloid spores and the fruitbodies are small or very small and whitish; some are without gills and form a link to the cyphelloid fungi (page 1076).

Other similar fungi:

– omphalinoids and hygrocyboids with decurrent gills may look rather similar (pages 128 & 142).

– collybioids and marasmioids may also look similar, but these are mostly somewhat tougher or can revive after desiccation (pages 274 & 302).

– similar entolomatoids have rose-coloured spore-deposits (page 448).

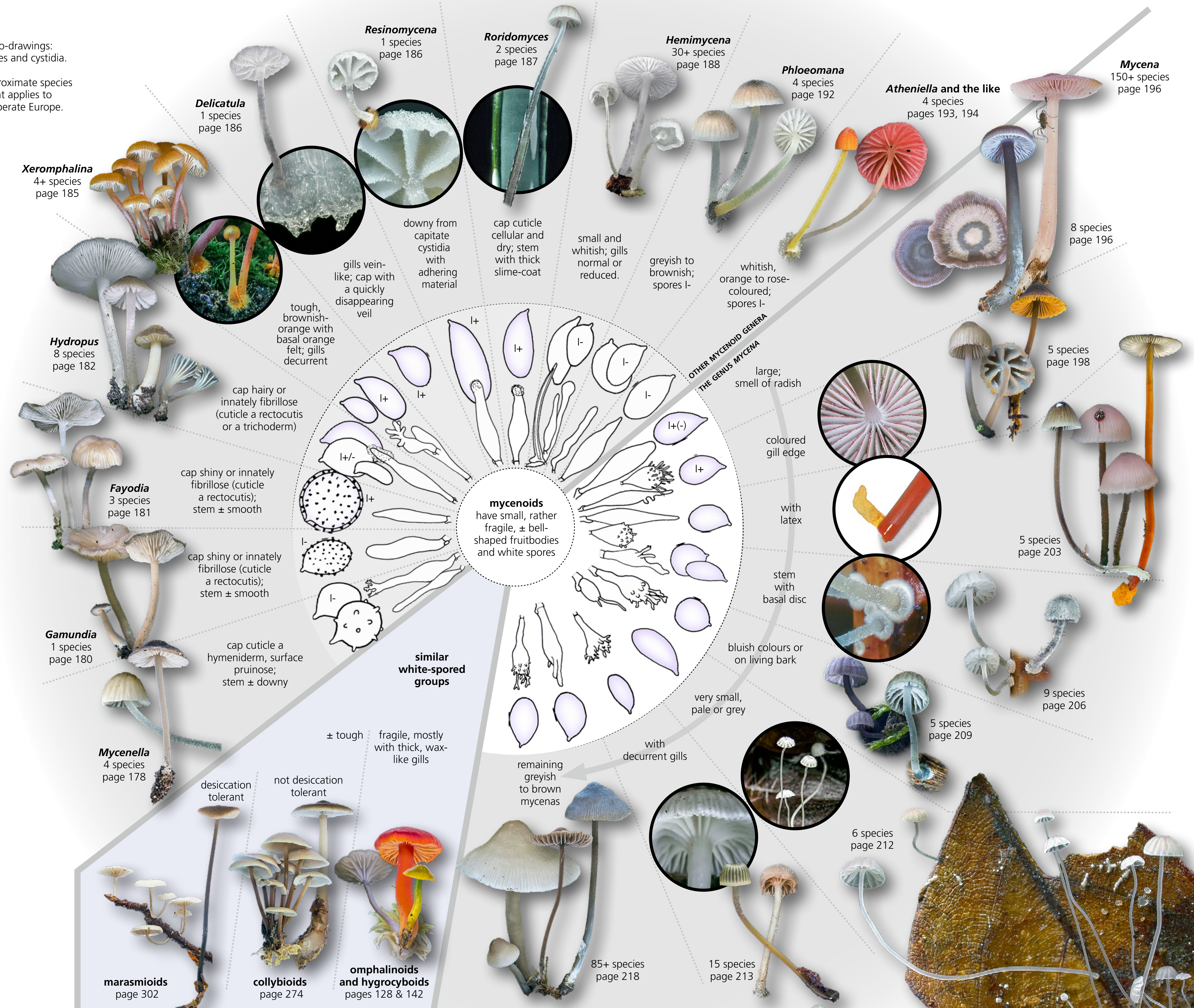
– similar *Panaeolus* species have blackish spore-deposits (page 554).

– similar little brown mushrooms (LBMs) have grey-brown to red-brown spore-deposits (page 616).

Further reading: 12, 15, 104, 156, 183, 206, 272, 273.

Micro-drawings: spores and cystidia.

Approximate species count applies to temperate Europe.



Tricholomatoids

The tricholomatoid fungi are rather fleshy agarics with ± solid stems, ± emarginate gills and whitish or, rarely, brownish-rose spore-deposits. The genera *Tricholoma* and *Catathelasma* form ectomycorrhiza, while species of *Squamanita* are parasites on other agarics. The remaining genera are decomposers (saprotrophs), although *Armillaria* may kill trees and bushes before degrading the wood (necrotrophs).

The tricholomatoid fungi have rather few reliable characters for separating the genera. Besides the spore morphology and the presense of veils, identification very much depends upon experience and gut feeling. It is, for example, relatively straightforward for an experienced field mycologist to recognize the elegant melanoleucas as such, but it is very difficult to put into words the macroscopical differences between a *Melanoleuca* and a *Lyophyllum*.

OTHER SIMILAR FUNGI:

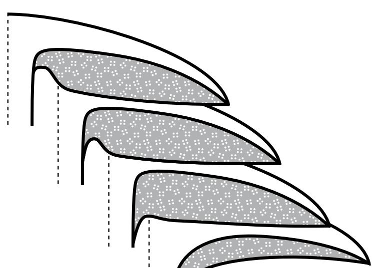
– the large, brown hygrocyboids in the genus *Neohygrocybe* are rather similar but have thick, wax-like gills (page 160).

– collybioids may look very similar, but are mostly more fragile with hollow stems, and typically have narrowly adnate gills (page 274).

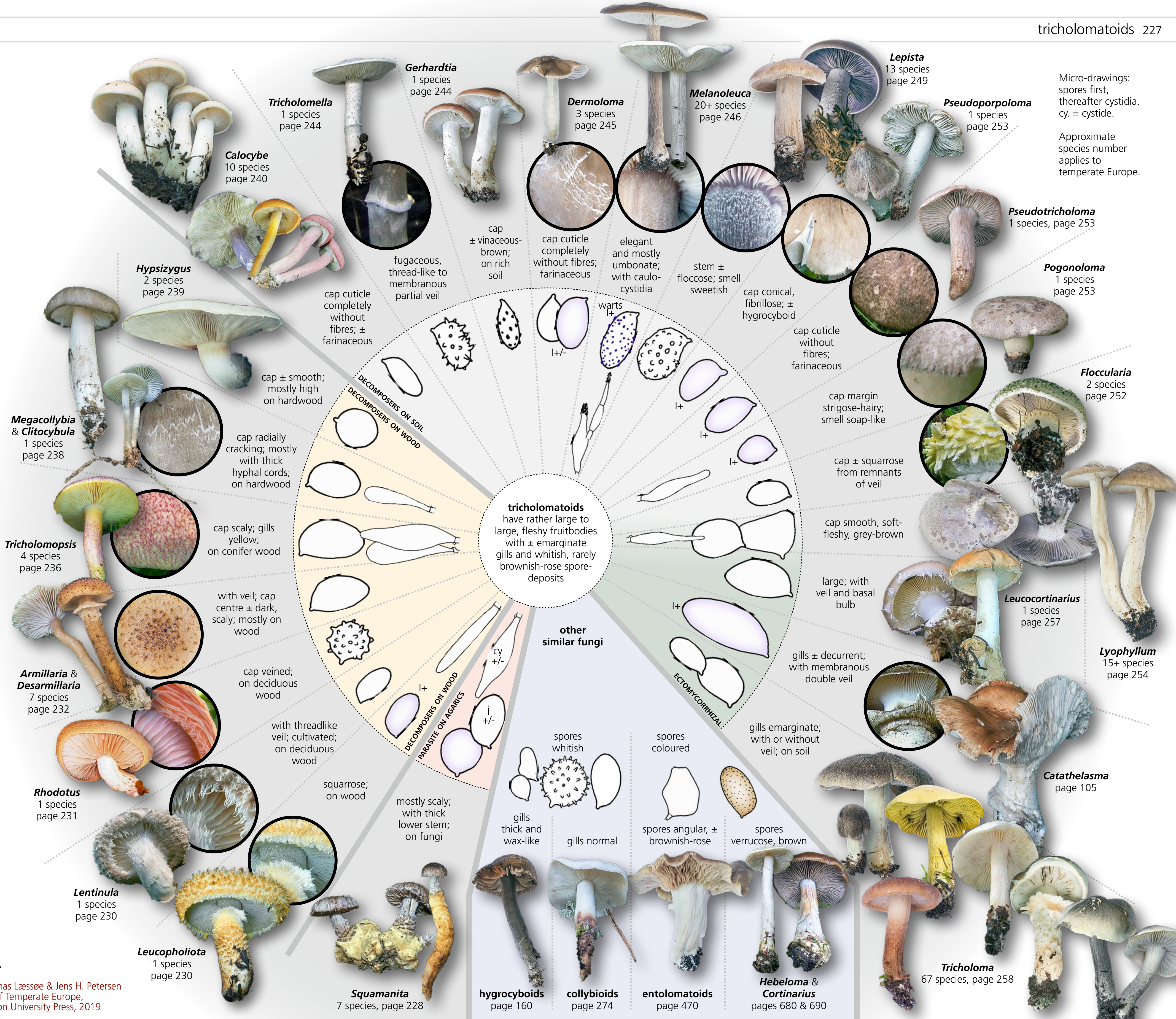
– species of *Entoloma* with robust fruitbodies are very similar, but have pinkish, angular spores (page 478).

– *Hebeloma* and *Cortinarius* may have the same stature, but brown spores (pages 680 & 690).

FURTHER READING: 28, 64, 88, 111, 156, 157, 181, 183, 285, 342, 343, 345.



types of emarginate gills



Collybioids

The collybioids are characterized by convex or umbonate to applanate, silky-fibrillose, greasy, hairy or slimy caps, adnexed to broadly adnate gills and white spore-deposits. *Rhodocollybia* has a pale grey-rose deposit and *Macrocystidia* may have a ± brown deposit. Most species are moderately tough. The spores are, with a few exceptions, inert to iodine.

The collybioids function predominantly as decomposers. A number of species have long, rooting stems, which arise from buried substrates such as tree roots or buried cones. *Laccaria* differs by being important ectomycorrhizals.

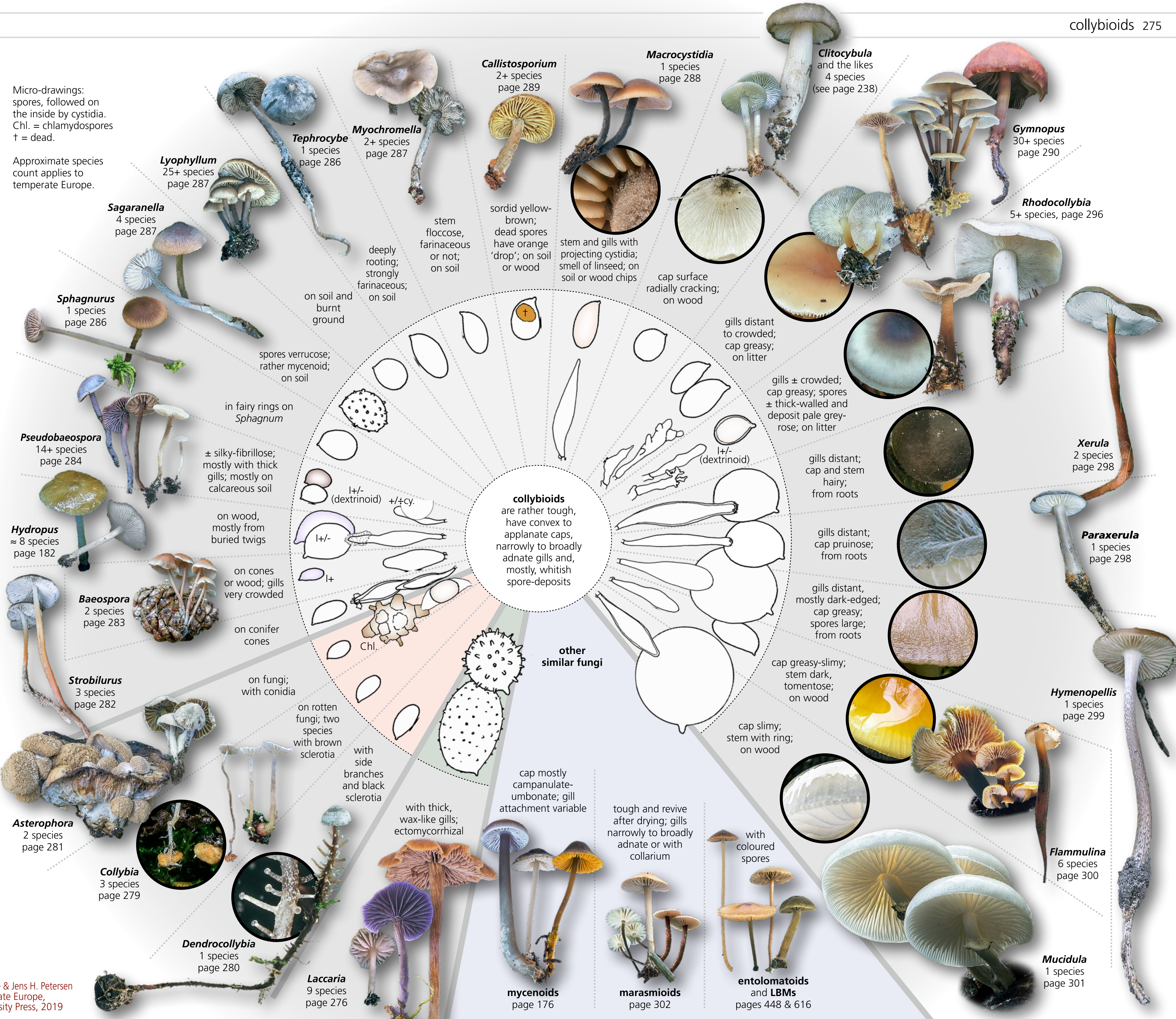
In older literature many collybioid species were included in the genera *Lyophyllum*, *Collybia* and *Xerula*. However, molecular phylogenetic studies have shown that these genera are all strongly polyphyletic, and this has led to much 'splitting', as can be seen from the many unfamilar names.

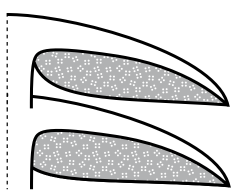
Other similar fungi:
– mycenoids with narrowly adnate gills may look very similar. However, they mostly have campanulate-umbonate caps, tend to be more fragile, and most species have amyloid spores (page 176).
– marasmioids are rather similar to the collybioids in shape and habitat, but most can tolerate desiccation. The stem is typically darker with a pale apex. They are also somewhat tougher (page 302).
– tricholomatoids are more fleshy and have ± emarginate gills (page 226).
– entolomatoids have brownish-rose spore-deposits and angular spores (page 448).
– LBMs (little brown mushrooms) may have collybioid shapes, but are brown-spored (page 616).

Further reading: 4, 13, 24, 25, 30, 156, 181, 183, 246, 348.

Micro-drawings: spores, followed on the inside by cystidia. Chl. = chlamydospores † = dead.

Approximate species count applies to temperate Europe.





adnexed to broadly adnate gills

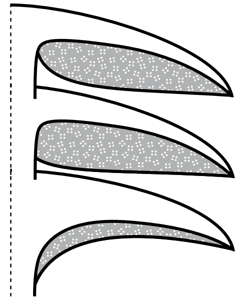
Marasmioids

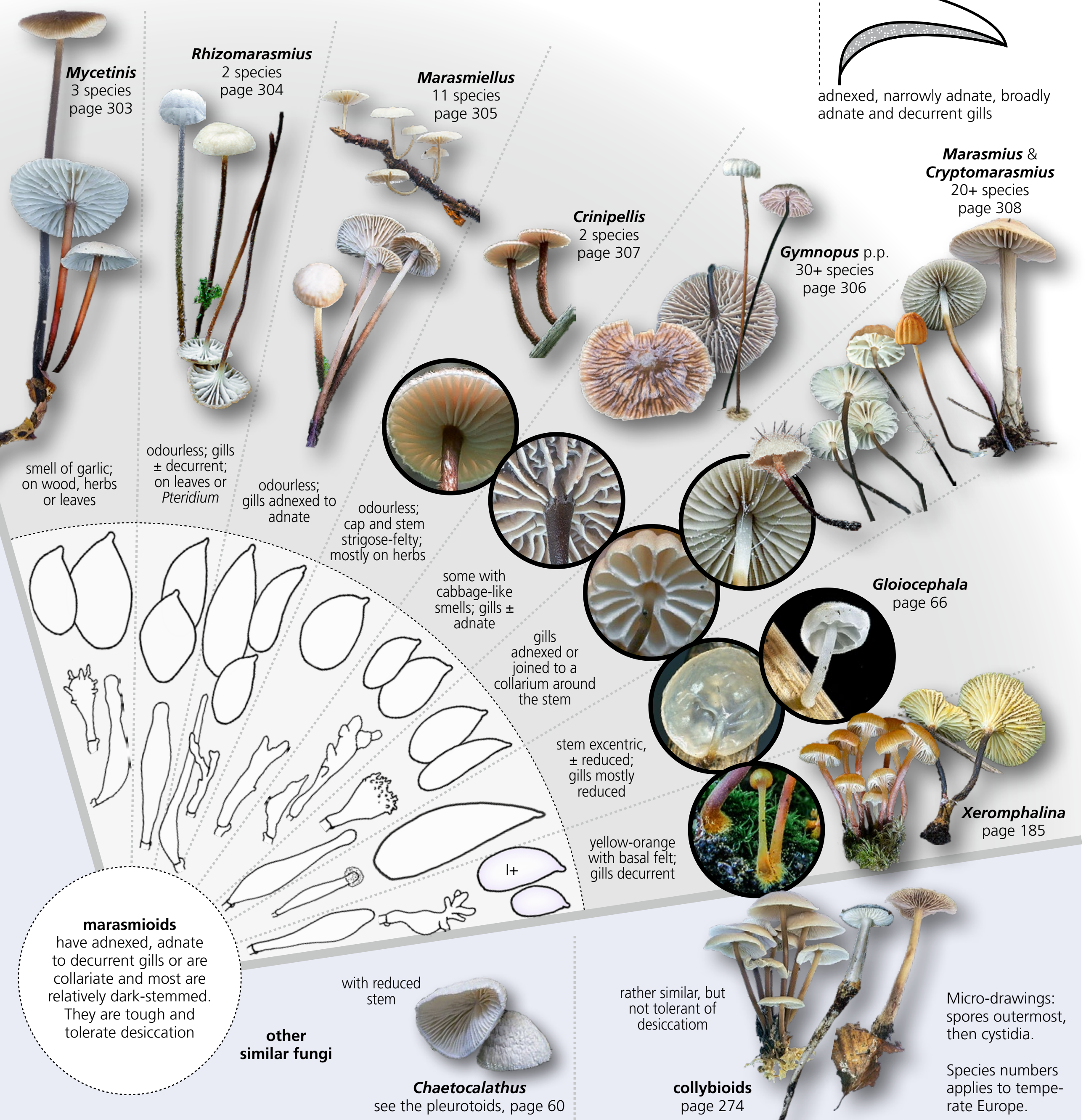
The marasmioid fungi have applanate to convex, rather tough caps and highly variable gill attachments, including a collarium around the stem (page 312). The stems are mostly dark, except for the apex, and some species have strong odours. The fruitbodies revive after desiccation. Microscopically many species have cystidia with finger-like protuberances.

The marasmioid fungi can be very difficult to distinguish from the collybioids, especially the genus *Gymnopus* (pages 290 & 306). Likewise, *Xeromphalina* (page 185) creates a bridge between marasmioids and mycenoids.

Other similar fungi:
– collybioids usually have adnexed gills and the stems are mostly not darker than the caps (page 274).
– marasmioid species without stem or with excentric stems are to be found amongst the pleurotoids (page 60).

Further reading: 13, 156, 181, 202.


adnexed, narrowly adnate, broadly adnate and decurrent gills



Mycetinis is recognized by the smell of stale garlic or old rubber-bands.

Mycetinis alliaceus is a large, tough, strongly garlic-smelling marasmioid with a very dark, finely felty-downy, stiff stem. The gills are pale and rather distant. The spores measure 7.5–11 × 6–8 µm. Almost exclusively on trunks and buried twigs of *Fagus*.

Mycetinis querceus ▽ is browner and occurs directly on leaf-litter. *Mycetinis alliaceus* var. *subtilis* ⋉ is a rather common dwarf form with a pale, marginally striate cap.

Widespread and very common in parts of temperate Europe, rare or absent from others; May–January.

Mycetinis querceus is a strongly garlic-smelling, large, pale marasmioid; the stem becomes felty towards the base. The spores measure 7–10 × 4–5 µm. Occurs mostly on *Quercus* leaf-litter late in the season (often Q. *rubra*), but also on *Fagus* leaf-litter.

Mycetinis alliaceus △ has darker stems, grows on wood and, in comparison to *M. querceus*, has cheilocystidia. *Mycetinis scorodonius* ▽ has a reddish, smooth stem. Similar species of *Gymnopus* (pages 290 & 306) are either odourless or have a cabbage-like smell.

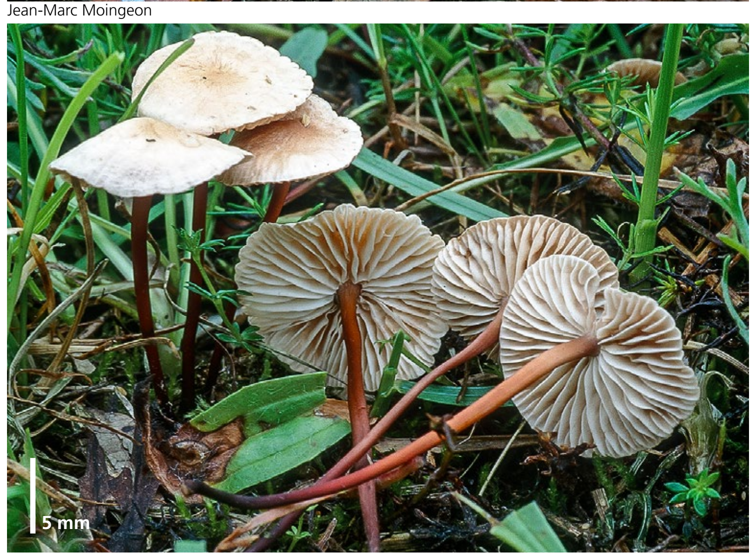
Widespread, but mostly rather uncommon; mainly October–January.

Jean-Marc Moingeon

Mycetinis scorodonius is a medium-sized marasmioid with a shiny, reddish stem, pale cap and a strong garlic smell. Spores 7–10 × 3–5 µm. Occurs in open, dry places, *e.g.* in dunes, and can be found on *e.g.* stems of *Artemisia campestris* and similar coarse herbs, but occasionally also on wood, *e.g.* in *Syringa* hedgerows.

Crinipellis scabellus ▷▷ occurs in the same habitats but has projecting hairs on the stem and is odourless. *Marasmius oreades* ▷▷ is less red and has a different smell. Other *Mycetinis* species have ± felty stems, are larger and more bound to woodland.

Widespread and rather common; mainly July–November.



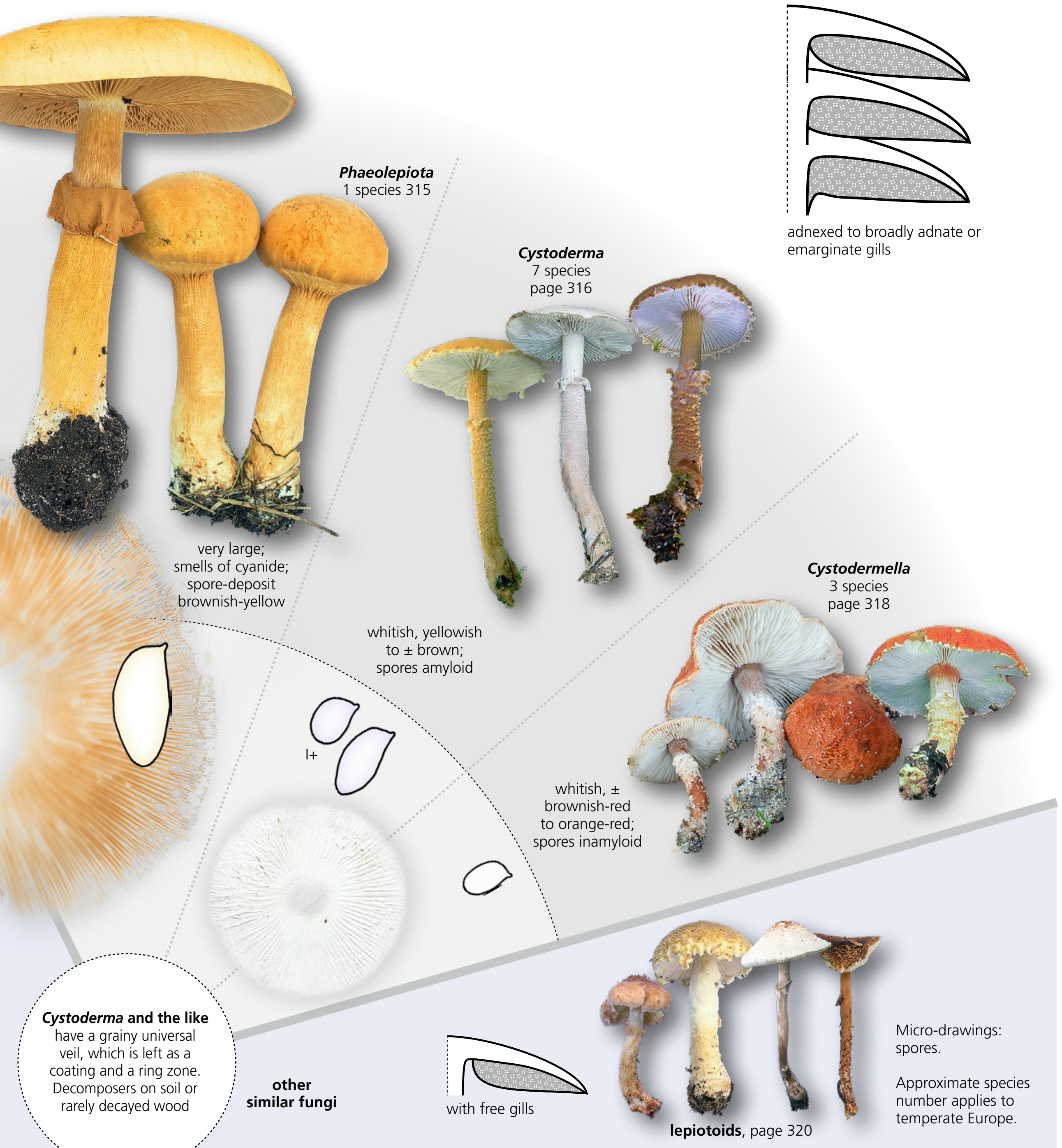
Cystoderma and the like

This group is characterized by the granulose surface of the cap and stem that constitutes remnants of a universal veil. In some species a ring or ringzone is present on the stem. The gills are adnexed, adnate or emarginate and the spore-deposit is either whitish or brownish-yellow. The spores are amyloid or inamyloid and smooth. The flesh may contain asexual spores. Some species have hymenial cystidia.

Other similar fungi:
– the lepiotoids have completely free gills (page 320).

Further reading: 156, 181, 324.

Left: young caps. Right: expanded caps with remnants of veil at the margin.



Phaeolepiota aurea is a large, fleshy, completely dry, orange-yellow agaric with a large, flaring to hanging ring, the upperside of which is ± coloured by the brownish-yellow spores. The entire fruitbody is mealy-grainy. The gills are adnexed. The odour may be somewhat like cyanide or bitter almonds. The spores are fusiform, smooth, and measure 11–12 × 4.5–5.5 µm. Occurs on rich, often disturbed, soils, *e.g.* in fertilized lawns or stands of nettles, typically in troops and fairy rings.

Could possibly be confused with the ± fibrillose *Gymnopilus spectabilis* (page 602) but that species has ornamented spores and grows on wood. It may also recall an enlarged *Cystoderma* ▷▷ or *Cystodermella* ▷▷ but the spore-deposit colour is distinctive. In Japan it is parasitized by a species of *Squamanita* (page 228), which may reflect its close relationship with *Cystoderma*, a common host for this parasitic genus of agarics.

Widespread and locally common, more or less absent from the boreal zone; mainly September–November.

Lepiotoids

The lepiotoids have whitish or greenish spore-deposits and free gills but the universal veil is less membranous in comparison to the amanitoids, p. 352. In some species the universal veil is powdery or granulose, sometimes in the form of small spines. Often have complex, muff-like rings formed by parts of both the universal and the partial veil. The spores are often dextrinoid.

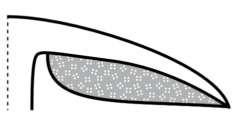
The lepiotoids are decomposers and are mostly found on black, mull soils, *e.g.* in damp, rich woodlands, along road-sides with *Urtica*, in scrub and gardens, and on old compost. Some species of *Macrolepiota*, *Chlorophyllum* and *Lepiota* also grow in open dry grasslands, including dunes.

The smaller lepiotoids apparently need a specific climatic scenario in order to produce fruitbodies, and years may pass without significant fruiting. When this does happens it is often over in a week or two.

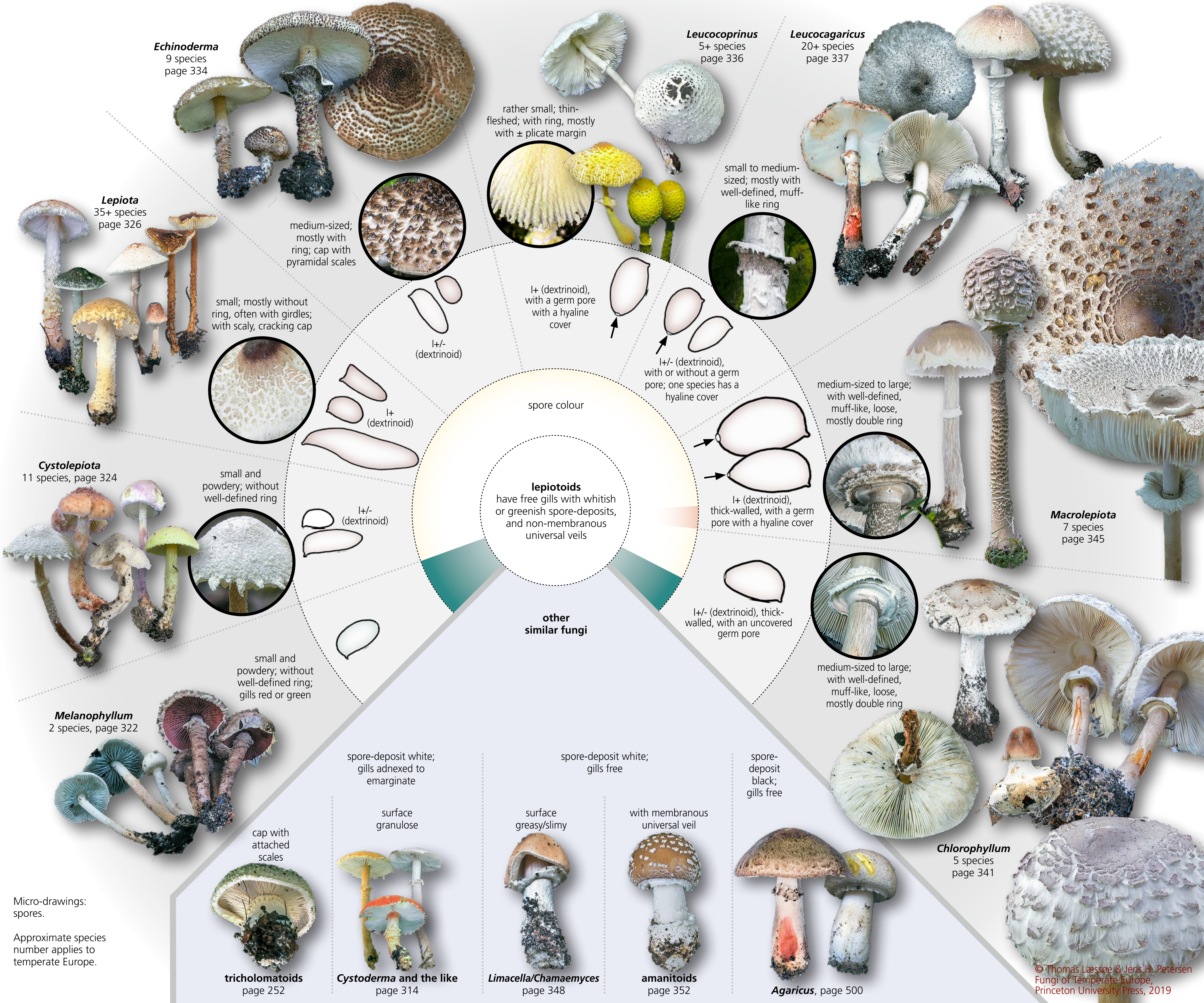
Other similar fungi:

– the amanitoids are similar but have a membranous universal veil (page 352).
– *Limacella* and *Chamaemyces* may look similar but have a greasy/slimy cap surface (page 348).
– *Cystoderma* and others have adnexed to emarginate gills (page 314).
– *Flocculария* has adnexed to emarginate gills (page 252).
– *Agaricus* (page 500) has black spores. Young fruitbodies of *e.g. A. sylvicola*, with immature spores, can be recognized by the sweet marzipan smells. Reddning species may recall species of *Chlorophyllum*, but these have more complex rings.

Further reading: 6, 85, 156, 183, 226, 332.



free gills



Chamaemyces and *Limacella*

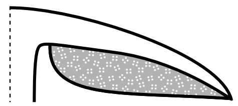
These genera are characterized by ± free gills, white spore-deposits and the absence of a membranous universal veil, although some species may have a slimy universal veil. They have membranous or thread-like partial veils left as a ring or ring zone on the stem. The cap surfaces are smooth, do not crack, and are mostly greasy to slimy.

Chamaemyces and *Limacella* are decomposers, which occur mostly in exceptionally mull-rich habitats in scrub and forests. Most, perhaps all, species are associated with calcareous soils.

Chamaemyces is closely related to the lepiotoids (page 320), while *Limacella* is relatively close to the amanitoids (page 352).

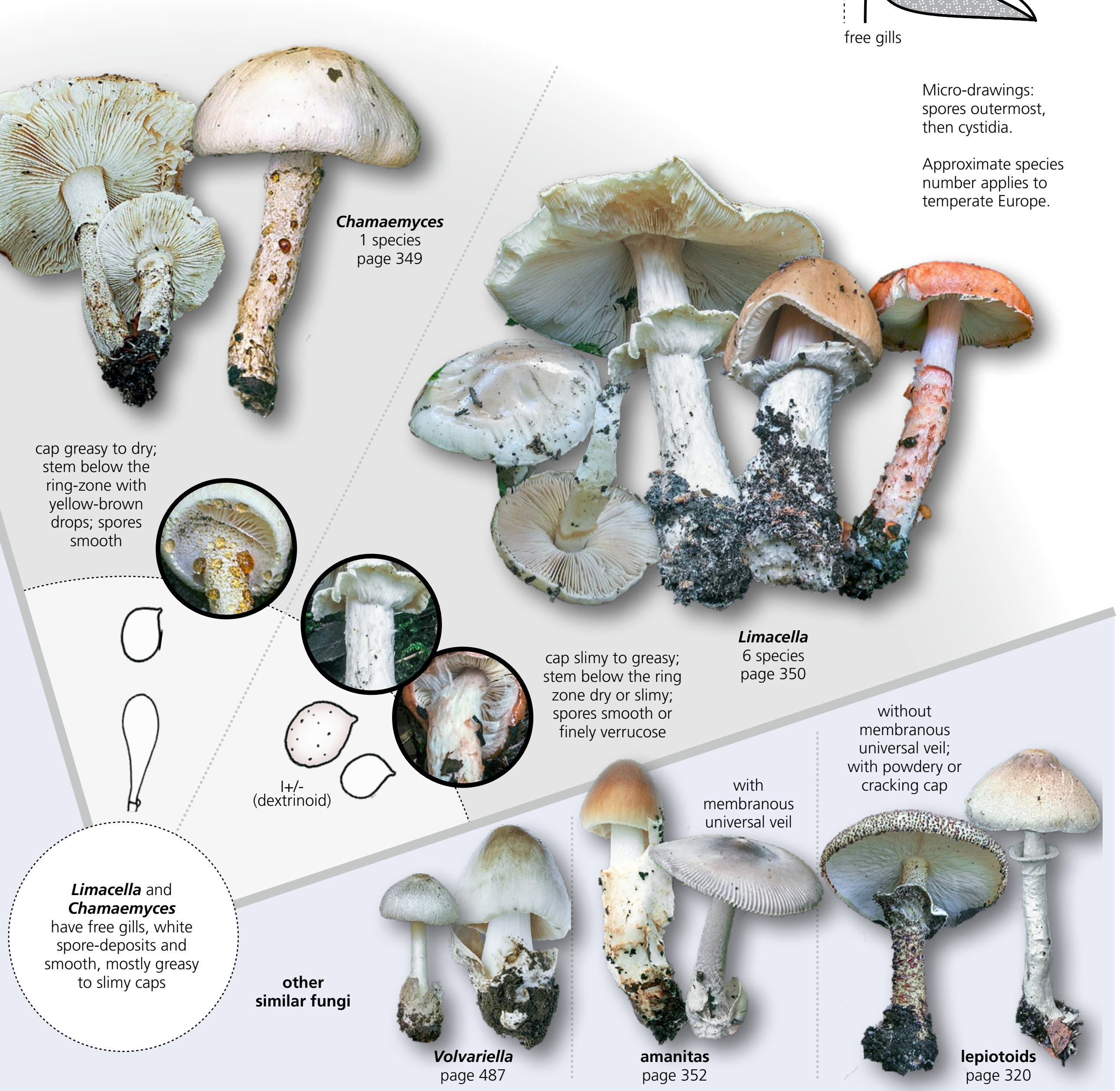
Other similar fungi:
– the amanitoids have ± free gills and a membranous universal veil that covers the greasy cap (page 352).
– volvariellas have free gills, a membranous universal veil seen as a volva, and a brownish-rose spore-deposit (page 487).
– the lepiotoids have free gills and powdered, plicate, scaly or cracking, dry, cap surfaces (page 320).

Further reading: 90, 156, 181.



Micro-drawings: spores outermost, then cystidia.

Approximate species number applies to temperate Europe.



Thomas Læssøe

Chamaemyces fracidus recalls something between an *Amanita* and a *Limacella*, but it is easily recognized by the grainy-scaly covering below the ring-zone and by the wet, mostly guttulate, convex, pale buff cap, which may have remnants of a veil at the margin. The stem is also ± covered in yellow-brown drops. The whitish gills are free to almost free. The odour is strong, ± gas-like or sour. Has clavate cheilo- and pleurocystidia. The spores are smooth, inert to iodine, measure 4.5–5.5 × 2.5–4 µm, and lack a germ pore. Occurs on calcareous soils in deciduous forests (typically *Fagus*), mostly in sites with numerous other rare species of fungi.

This species also goes by the name *Lepiotella irrorata*. It may recall *Echinoderma hystrix* (page 335), but that species has pyramidal, brown scales on the cap. Farther south a darker type, *Chamaemyces fracidus* f. *pseudocastanea*, can be found.

Rather rare and local, absent from the boreal zone; mainly July–October.

Martin Kříž

Amanitoids

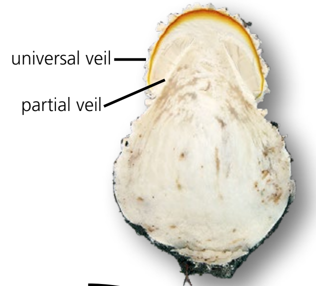
The amanitoids are recognized by free, or more rarely, adnexed gills, whitish or somewhat greenish spore-deposits and, almost always, a membranous universal veil (velum), which, at maturity, may be seen as a volva at the base of the stem and/or as loose patches on the cap. The spores may be amyloid or inamyloid.

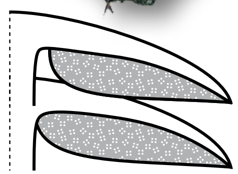
Most of the amanitoids form ectomycorrhiza and are, therefore, usually found in forests and parks. The genus *Saproamanita* is saprotrophic.

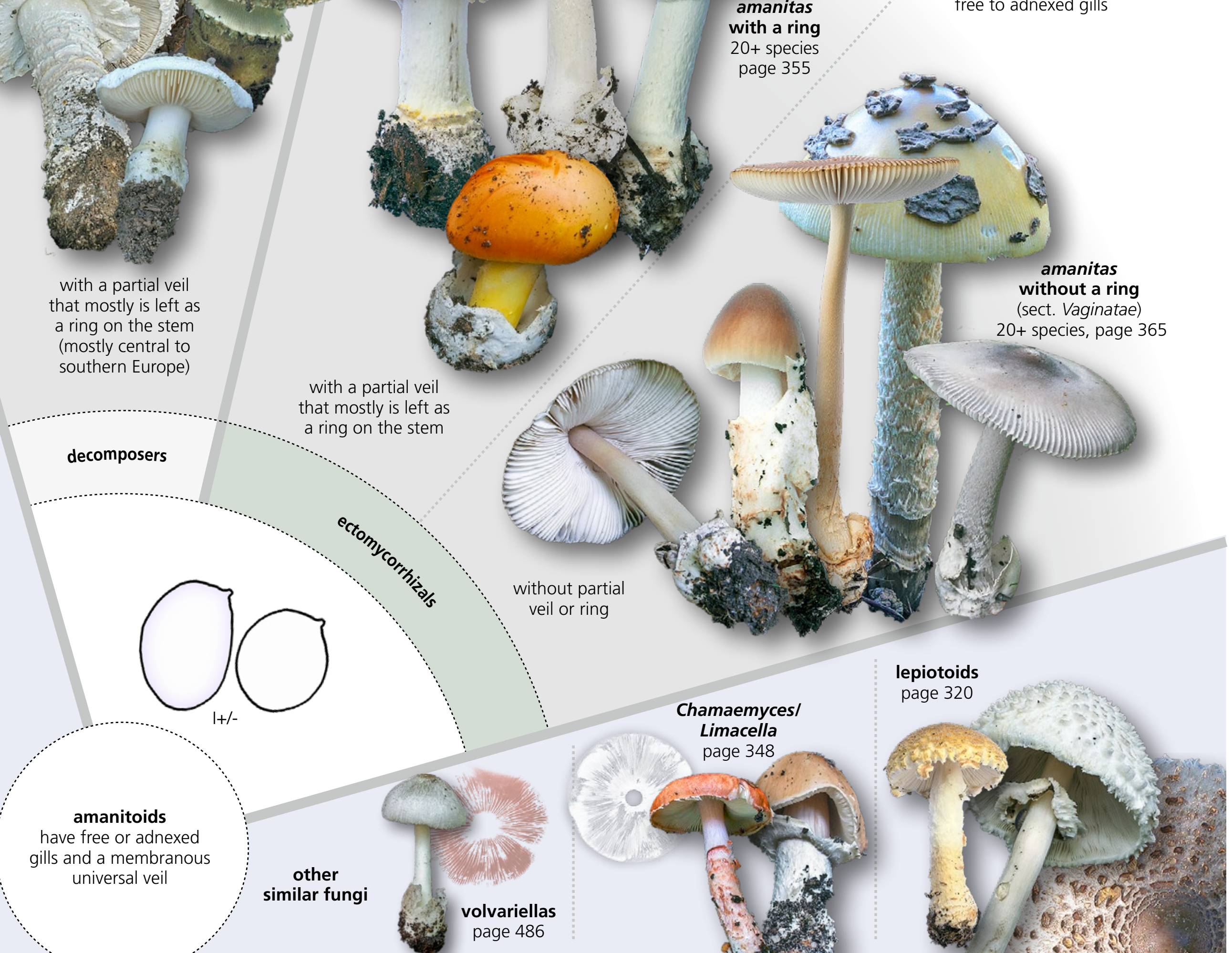
Amanita is a species-rich genus that includes some of the most notorious poisonous mushrooms, not least the ringless species (*Amanita* sect. *Vaginatae*) which form a very confusing group where specific identification can be difficult.

Other similar fungi:
– the lepiotoids have either a powdery universal veil, or it is absent (page 320).
– limacelloids are rather similar, but have a slimy universal veil (page 348).
– volvariellas are separated by their brownish-rose spores (page 486).

Further reading: 149, 156, 183, 218, 263, 281.




free to adnexed gills

Emilio Pini

Saproamanita are decomposing *Amanita*-like agarics. They usually occur in open land and mostly form fairy rings.

Saproamanita vittadinii is a magnificent, ± white to pale buff amanitoid with highly projecting scales on the cap and stem. The stem also has white to pale buff belts along almost its entire length; it lacks a bulb but does have have a complex ring. The gills are tinted buff or green. The spores are ellipsoid, amyloid and measure (9–)10–13 (–15) × (6.5–)7.5–10(–11) µm. Occurs in fairy rings without connections to mycorrhizal trees or scrub.

The mycorrhizal *Amanita solitaria* ▷▷ is very similar, but has echinulate scales on the lower part of the stem.

Mainly a southern species but reaches as far north as the Netherlands and central England; autumn.


Emilio Pini

Russula

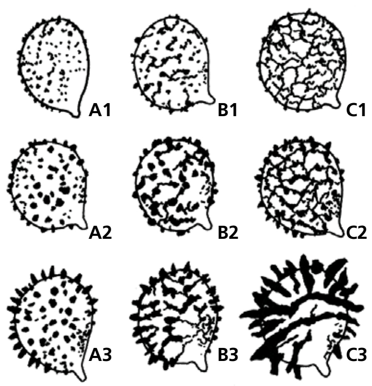
Russula is a genus of fleshy agarics with fragile flesh, and spores that have amyloid ornaments. The spore-deposit is white to orange-yellow.

A difficult genus. Among the most important macroscopical characters are the cap colour, the colour of the spore-deposit, the taste and the smell. However, the cap colours can be variable, since the pigments are water-soluble and easily washes out. The spore colour must be judged by obtaining a thick spore-deposit. The taste is fairly constant; some species are burning hot like strong chilli but for the milder species it is necessary to chew on a suitably large sample for some time. There exist also truffle-like species of *Russula* (see page 1266).

Russulas form ectomycorrhiza. Some species may grow with many different tree species, while others are ± limited to partners of certain genera. It is therefore important to note which ectomycorrhizal trees and bushes are present in the vicinity of a fruiting *Russula*. Mild-tasting russulas are considered edible but only a few are really choice edibles.

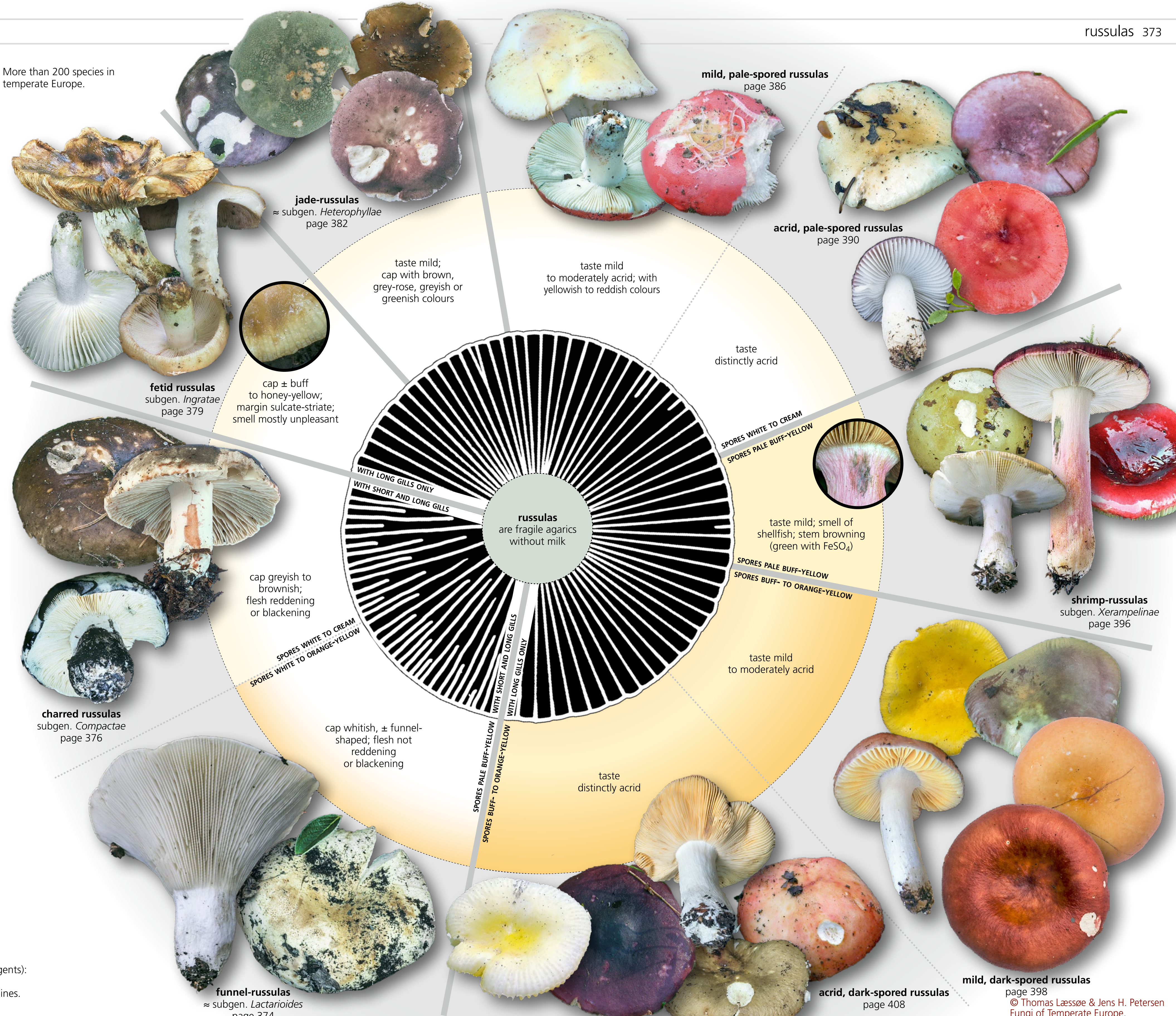
Other similar fungi:
– lactarioids have a similar fragile flesh and spores with similar ornaments, but the flesh exudes a white or coloured latex when cut (page 414).
– *Paxillus* and *Gomphidius* can have fragile flesh, but the spores are brown to black (pages 596 & 756).

Further reading: 76, 92, 151, 156, 165, 191, 228, 276, 287, 288.



Spore types (ornament stained with iodine reagents): column A with isolated warts or spines. column B with somewhat connected warts or spines. column C with reticulum (C1–C2) or crests (C3).

More than 200 species in temperate Europe.



Lactarioids

The genera *Lactarius* and *Lactifluus* are recognized by their fleshy fruitbodies with milk. They have the same fragile flesh as the genus *Russula*, and similar spores with a very amyloid ornament of spines, reticulae or crests. Most species also have large cystidia on the gills. Some are mild-tasting but many are very acrid.

The most important characters for species identification are the colour and stain of the milk, surface texture of the cap (including the degree of sliminess), overall colour, taste and mycorrhizal partner.

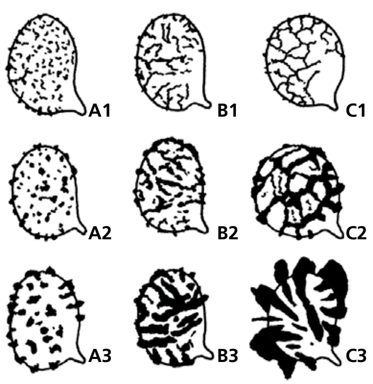
All lactarioids are mycorrhizal with trees and shrubs or, in the alpine zone, with *e.g. Dryas* and *Salix herbacea*.

The lactarioids are very closely related to *Russula*, and in the tropics the genera are less easy to differentiate.

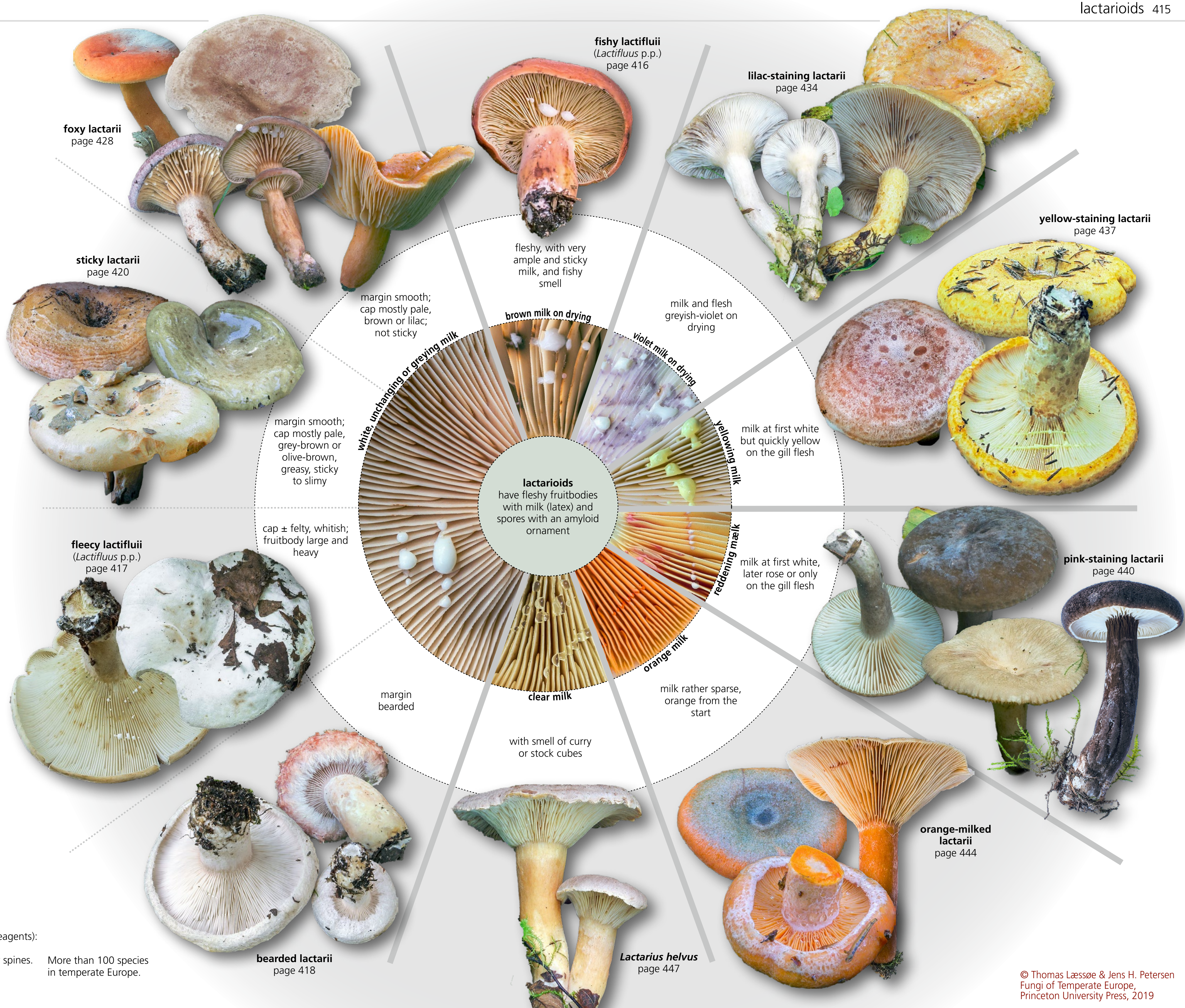
With the exception of *Lactarius helvus*, which smells like curry and is slightly toxic, all mild-tasting European lactarioids are edible. However, the acrid lactarioids are toxic and some contain strong mutagens.

Other similar fungi:
– some *Mycena* species have milk, but the stems are less than 2 mm wide (page 203).
– in the subtropics/tropics other agarics, *e.g. Lactocollybia* ⋉, may have latex.

Further reading: 92, 105, 152, 156, 165, 228, 327.



Spore types (ornament stained with iodine-reagents):
Column A with isolated warts or spines.
Column B with somewhat connected warts or spines.
Column C with reticulum or crests (C3).



More than 100 species in temperate Europe.

Entolomatoids

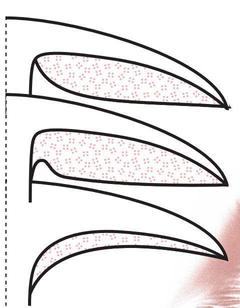
This group includes the genus *Entoloma* in a broad sense and the closely related genera *Clitopilus*, *Clitopilopsis*, *Clitocella*, *Rhodophana* and *Rhodocybe*. They are characterized by adnexed-adnate, emarginate to decurrent gills and ± brownish-rose spore-deposits. The spores are either verrucose, striate-ridged or three-dimentionally angular (faceted). An important character of entolomatoids is whether the pigment in the cap cuticle is incrusted or intracellular. Species with excentric or lateral stems are treated under the pleurotoid fungi (page 88).

Some species apparently have a parasite-like association with plants in the *Rosaceae,* while other species around *Entoloma rhodopolium* are mycorrhizal. The ecology of many species is still not known.

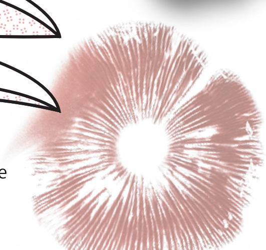
All genera belong in the same family, the *Entolomataceae*.

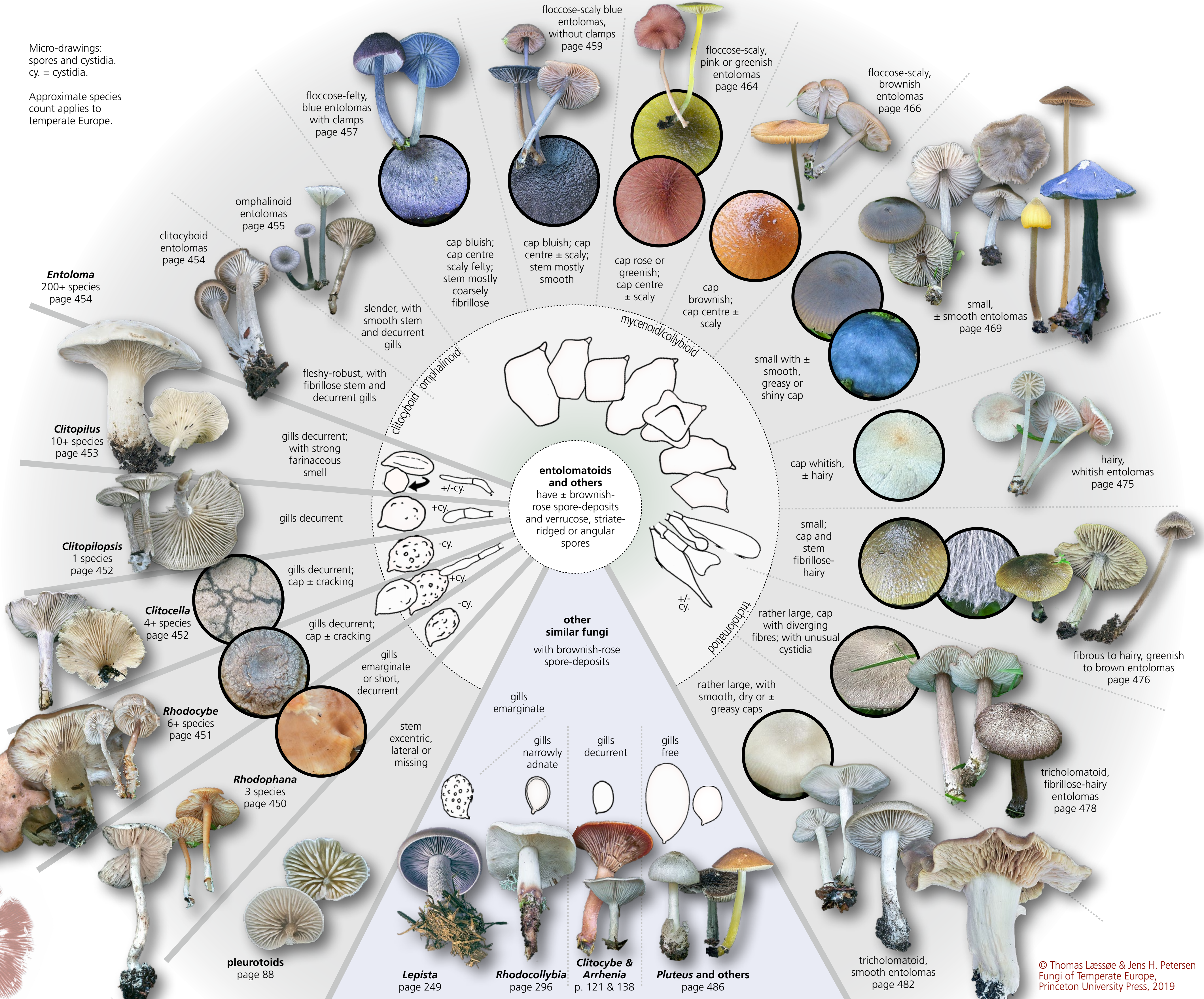
Other similar fungi:
– *Pluteus*, *Volvariella* & *Volvopluteus* have the same spore colour but free gills (page 486).
– some species of *Lepista* have brownish-rose spores and tricholomatoid fruitbodies. They are recognized by their minutely warty spores and a characteristic sweetish smell (page 249).
– some clitocyboids and the omphalinoid *Arrhenia discorosea* have ± brownish-rose, smooth spores (pages 98 & 138).
– the large collybioids in the genus *Rhodocollybia* have somewhat brownish -rose, smooth spores (page 296).

Further reading: 45, 89, 156, 158, 181, 182, 204, 223, 224, 335, 336, 337, 338.



adnexed, emarginate and decurrent gills





Pluteoids

Volvopluteus, *Volvariella* and *Pluteus* are characterized by their free gills and brownish-rose spore-deposits. They are decomposers either of wood or organic material in the soil. One species, *Volvariella surrecta*, is a parasite on fruitbodies of *Clitocybe nebularis*.

OTHER SIMILAR FUNGI:
– *Amanita* has white spore-deposits and the poisonous species have a partial veil that is left as a ring on the stem (page 352).
– *Limacella* is ± sticky and has white spore-deposits and no volva at the base (page 348).
– *Leucoagaricus leucothites* has pinkish gills, white spores, and a ring but no volva (page 339).
– entolomatoids have attached gills and ridged or angular spores (page 448).

FURTHER READING: 6, 89,140, 141, 156, 182.

Volvopluteus gloiocephalus is a large agaric with a smooth, greasy to slimy, greyish cap surface, a long, greyish stem and a rather large, white volva (the remnants of the universal veil) at the base. The spore-deposit is brownish-rose. Cheilocystidia clavate. The spores are smooth and measure 10.5–17.5 × 6.5–9 µm. Mostly found in disturbed places, including stubble fields, compost heaps, bales of damp straw, *etc.* It can occur by the thousands in stubble and in newly sown fields late in the season.

The amanitoids (page 352) usually have the same greasy-smooth cap surface but they are generally ectomycorrhizal and have white spores; the most similar species, *Amanita phalloides* (page 359), has a ring on the stem. Species of *Volvariella* ▷▷ are dry to somewhat sticky on the cap and always distinctly radially fibrillose. Species of *Pluteus* ▷▷ lack a universal veil and thus a volva.

Widespread and common, decreasing towards the north; May–December.

Agaricus and *Allopsalliota*

The genera *Agaricus* and *Allopsalliota* are characterized by free, permanent, non-dissolving gills and dark chocolate-brown spore-deposits. Ink caps (*Coprinus*, *Coprinopsis* and *Coprinellus*, page 520) also have ± free gills and ± black spores, but their gills normally dissolve with maturiy.

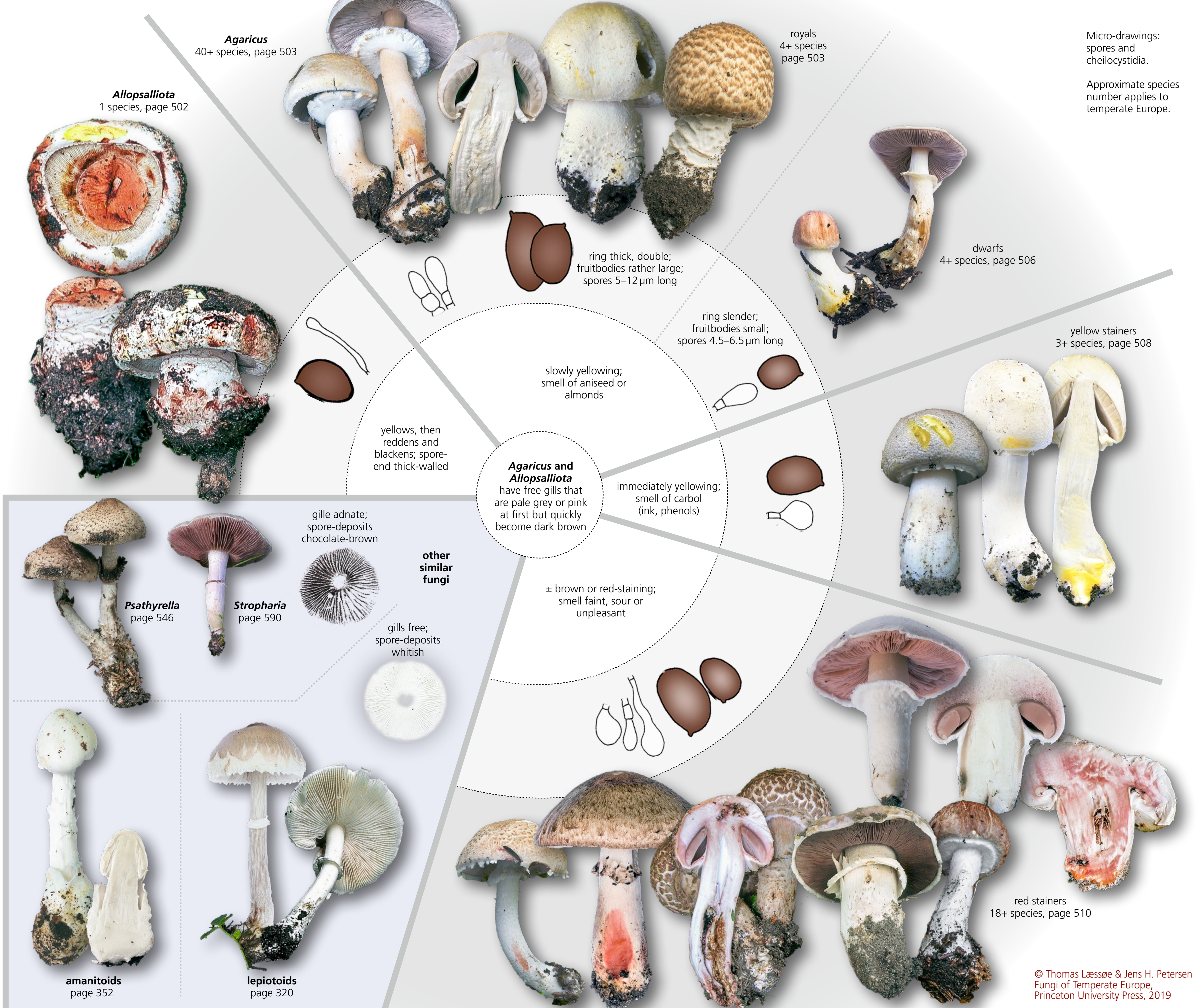
Molecular phylogenetic studies have led to descriptions of a large number of *Agaricus* species that cannot be recognized by morphological characters. Using traditional morphology, only 40+ broadly defined species can be keyed out in temperate Europe.

Agaricus and *Allopsalliota* are decomposers that often occur in fairy rings.

Many species are edible but the slowly yellowing species (the royals) may contain high levels of cadmium, and the yellow stainers can cause stomach upsets. In addition, most species contain potentially carcinogenic hydrazines (agaritin). Species of *Agaricus* should therefore only be consumed in fairly small amounts and then only when cooked.

Other similar fungi:
– *Stropharia coronilla* recalls a small, yellowish *Agaricus* but has narrowly adnate gills (page 590).
– annulate species of *Psathyrella* have narrowly adnate gills (page 546).
– similar lepiotoids have white spore-deposits (page 320).
– the very poisonous *Amanita virosa* has a membranous universal veil and a white spore-deposit, as do other species of *Amanita* (page 357).

Further reading: 91, 147, 148, 156, 182, 226, 236, 237.



Coprinoids

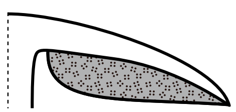
The coprinoids include the genera *Coprinus*, *Coprinellus*, *Coprinopsis* and *Parasola*, of which there are are more than 150 species in temperate Europe. They are recognized by the black spores and the almost always free gills. Many coprinoids also have a unique maturation process. The spores mature from the gill edges inwards and, as soon as the spores are released, that part of the gill disintegrates and becomes liquid, and so the process continues. This allows for very closely spaced gills, since the risk of spores being caught between them is reduced. Nevertheless, many spores are still caught and produce the inky liquid associated with the vernacular name ink cap. The coprinoids can be grouped according to the appearance of the surface of the cap and veil, *e.g.* whether the veil is grainy or thread-like. These characters are borderline between macro and micro, and a good hand lens is required. The coprinoids may produce many different spore types, from smooth and ellipsoid to lemon-shaped, heart-shaped or truncate and they may have prominent warts. They always have a germ pore and occasionally a loosening, colourless outer wall. All have cystidia.

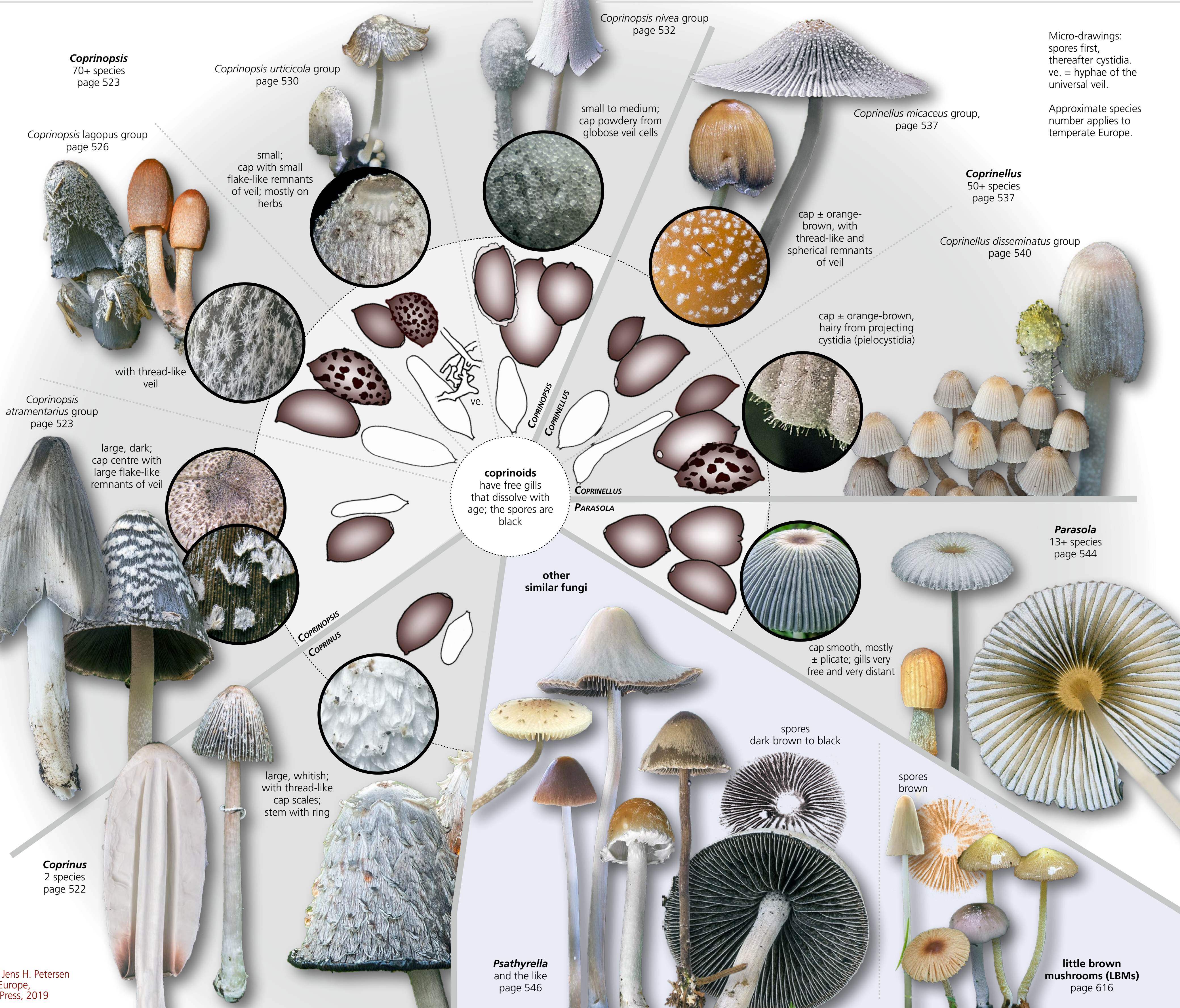
The phylogenetic and morphological differences between psathyrelloid (page 546) and coprinoid fungi are not straightforward. Some members of *e.g. Coprinopsis* do not have gills that dissolve and are treated among the psathyrelloids.

All coprinoids are decomposers and some coprophilous species have a very short life-cycle, fruiting just a few weeks after spore germination. All fruitbodies are very short-lived. At least some of the coprilous species are able to kill competing mycelia in the substrate.

Other similar fungi:
– *Psathyrella* and the like mostly have adnate gills that never dissolve during maturation (page 546).
– *Bolbitius* are slimy-capped and have brown spore-deposits (page 618).

Further reading: 156, 182, 207, 208, 227, 290, 322.


free gills



Psathyrelloids

A group of very fragile agarics, most with black to dark brown, rarely more grey-brown, spore-deposits, mostly dry caps with dull brownish colours, and adnexed, adnate to shortly decurrent gills. A few species have prominent stem rings but most have veil remnants on the cap or, rarely, no veil at all. It includes a number of genera formerly treated in *Psathyrella*: *Cystoagaricus*, *Homophron*, *Kaufmannia*, *Lacrymaria* and *Typhrasa*, as well as the ± classic genera *Panaeolus*, *Psilocybe*, *Deconica* and part of *Parasola*.

Microscopically, most species have spores with germ pores. In rare cases the spores are ornamented (*Lacrymaria*, *Panaeolus* p.p.). Shape and contents of the cystidia (cheilo- and pleurocystidia) are important for species identification.

Ecologically, vary from lignicolous over soil to dung-inhabiting, and one species is a parasite on *Pluteus*.

OTHER SIMILAR FUNGI:

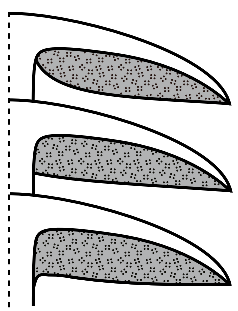
– coprinoids have ± dissolving gills (page 520).

– other black-spored agarics, *e.g.* *Stropharia*, *Leratiomyces* and *Hypholoma*), have mostly more vivid colours and often slimy caps (page 580).

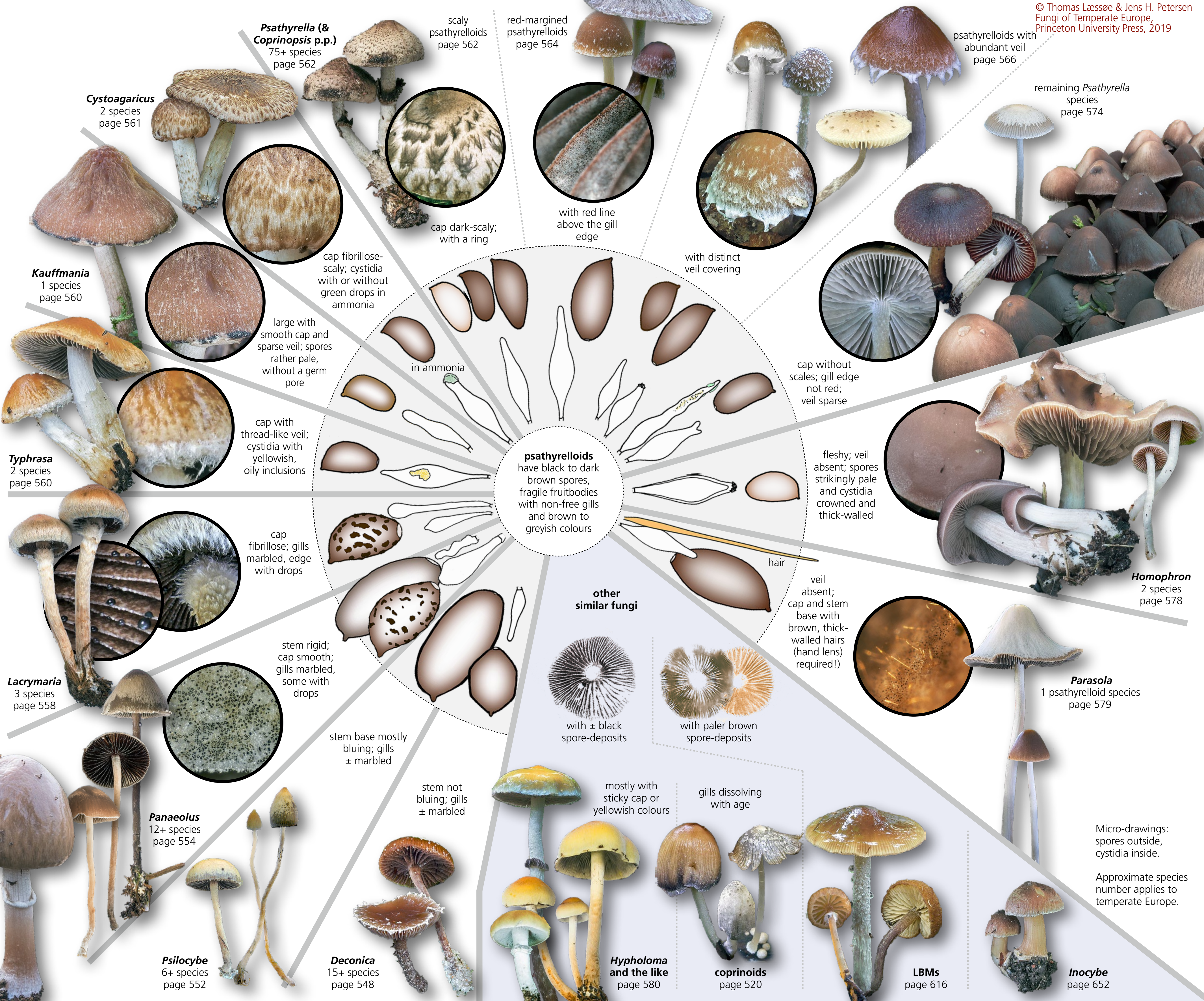
– *Inocybe* has grey-brown spore-deposits (page 652).

– *Agrocybe* has somewhat paler, grey-brown spore-deposits and mostly sticky cap surfaces (page 625).

FURTHER READING: 86, 154, 155, 156, 171, 182, 225, 370.



adnexed, adnate and decurrent gills



Hypholomatoids

This group includes mostly fairly robust agarics with dark chocolate-brown to black spore-deposits and adnate, emarginate or slightly decurrent gills. The caps are mostly slimy and the colours a rather vivid yellowish, greenish or orange-brown. With the exception of *Hypholoma*, the gills are ± marbled due to uneven maturation.

Microscopically, many of the species have dark spores with a germ pore and many have cystidia with yellow contents (chrysocystidia). However, similar cystidia are also common in the brown-spored genus *Pholiota* (page 608).

All species are decomposers. The majority decay wood or wood chips, but a few are decomposers of herbs or *Sphagnum*.

OTHER SIMILAR FUNGI:

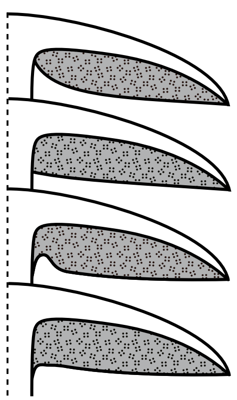
– psathyrelloids also have blackish spores but the fragile fruitbodies are less brightly coloured and the caps are mostly dry (page 546).

– gomphidioids are slimy with black spores and deeply decurrent gills (page 596).

– pholiotoids may be both slimy and yellow but have paler, grey-brown spores (page 600).

– the group of little brown mushrooms (LBMs) is separated by their paler brown spore colours (page 616).

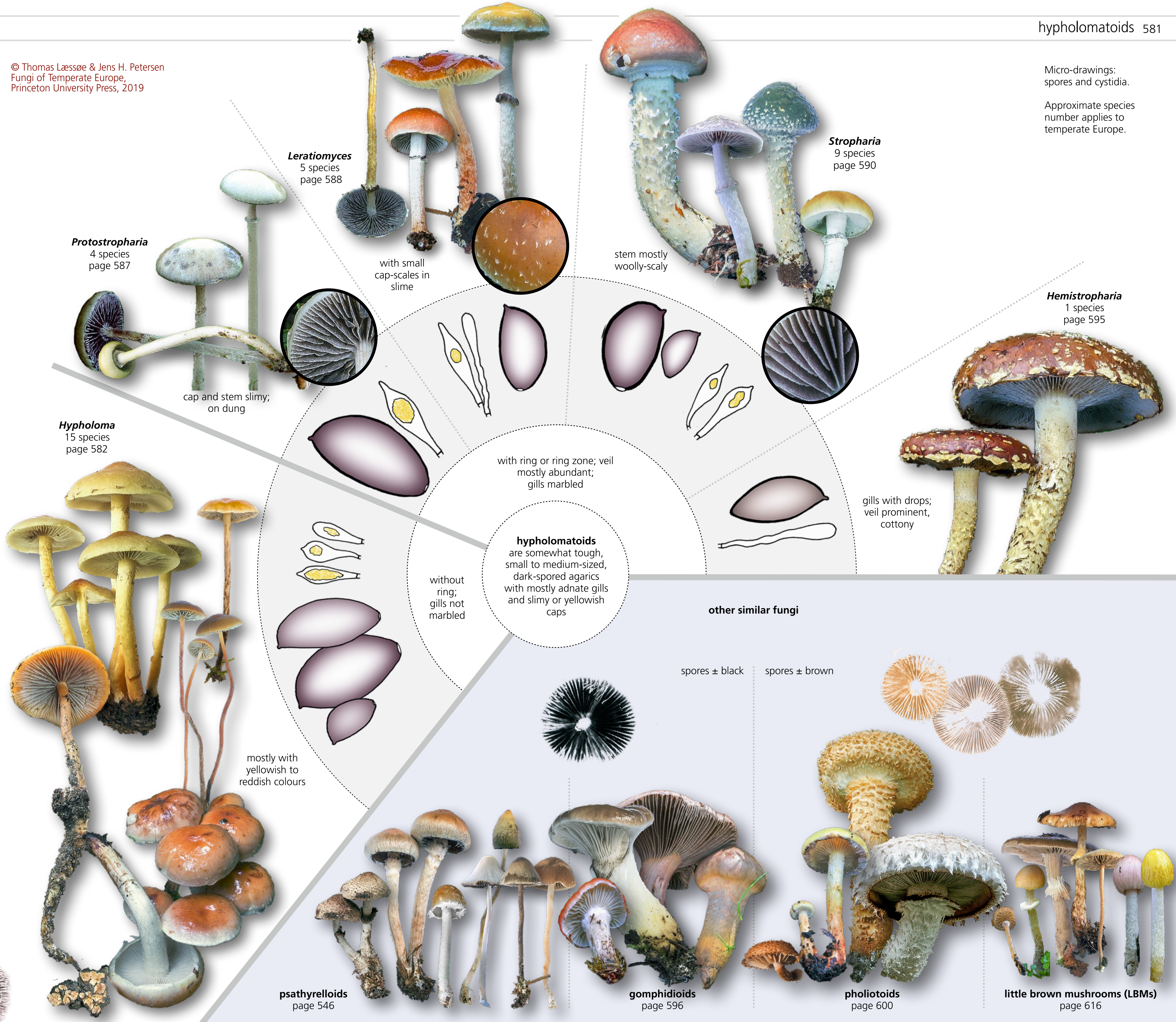
FURTHER READING: 156, 169, 181, 225.



adnexed, adnate, emarginate and shortly decurrent gills

Micro-drawings: spores and cystidia.

Approximate species number applies to temperate Europe.



Gomphidioids and *Melanomphalia*

This group includes agarics with dark brown to black spore-deposits and deeply decurrent gills. The two genera of gomphidioids, *Chroogomphus* and *Gomphidius*, have a ± slimy universal veil that covers the entire young fruitbody. They are related to the boletes and have long, somewhat fusiform, typical boletoid spores. The genus *Melanomphalia* has no veils and belongs to the *Agaricales*; it has finely dotted-verrucose spores.

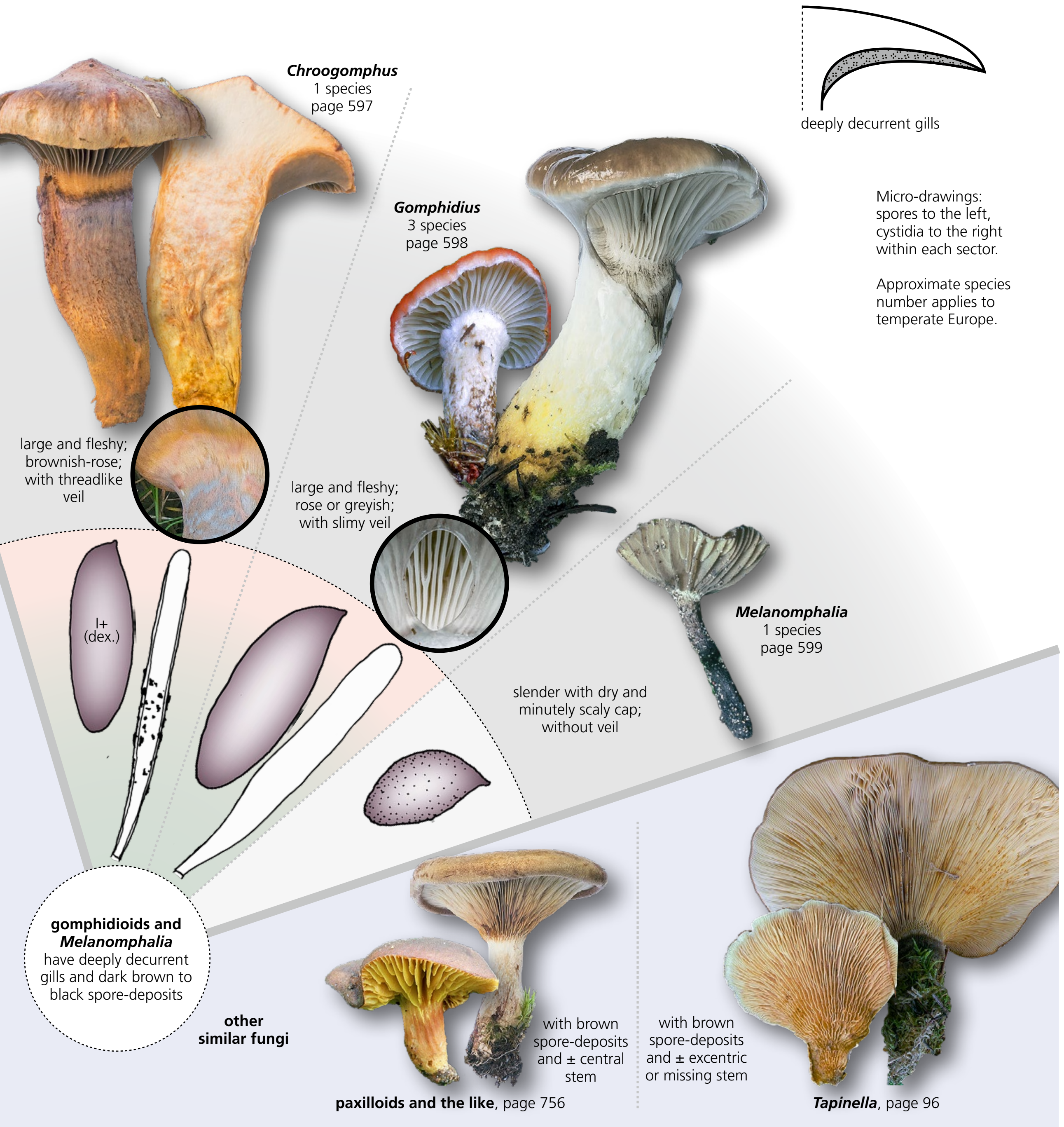
The species of gomphidioids are probably parasites on ectomycorrhizal fungi with conifers (boletes and *Rhizopogon*); the single species in *Melanomphalia* is presumed to be a decomposer.

Other similar fungi:
– *Paxillus* and *Phylloporus* are similar but have brown spore-deposits (page 756).
– *Tapinella* has a brown spore-deposit and a ± excentric or missing stem and grows on wood (page 96).

Further reading: 156, 181, 289.

Micro-drawings: spores to the left, cystidia to the right within each sector.

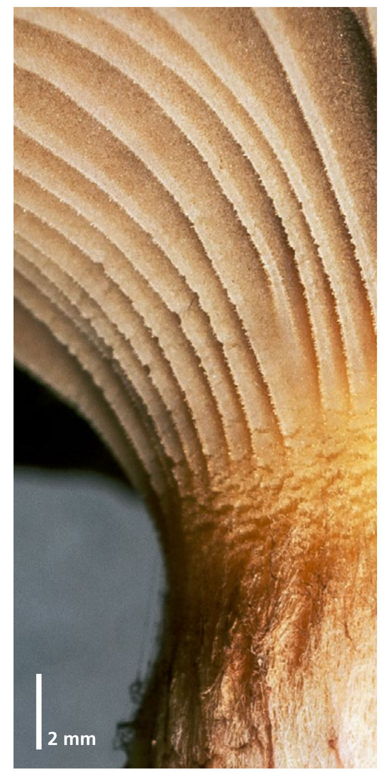
Approximate species number applies to temperate Europe.



***Chroogomphus rutilus* s.l.** is a sturdy, fleshy, red-brown, somewhat slimy to dry, almost black-spored agaric with deeply decurrent gills. The stem bears an indistinct ring zone from the ephemeral partial veil, and the flesh has wine-red tinges, but is yellower towards the base. The gills are fimbriate from cystidia. The spores are smooth, ± fusiform, ± dextrinoid and measure 15–22 × 5.5–7 µm. Always found with *Pinus*, but probably parasitic on species of *Suillus* (p. 796) that have *Pinus* as a mycorrhizal partner, e.g. *S. granulatus* (page 800).

Gomphidius glutinosus ▷▷ is more slimy and grey. Recent studies indicate that there are eight European species in the *Chroogomphus rutilus* complex. In the strict sense, *C. rutilus* should have rather crowded gills (upper picture); other species have more distant gills.

The distribution of the eight species is, as yet, unclear. As a whole they are widespread, rather common to occasional; June–November.



Pholiotoids

This group includes wood-inhabiting agarics with brown (grey-, ochre-, red- to orange-brown) spore-deposits. The principal genera are *Hemipholiota*, *Kuehneromyces*, *Pholiota* and *Gymnopilus*. Many of the species included are rather fleshy, with either slimy or scaly cap surfaces. A number of similar, but mainly terrestrial, genera are treated under the group 'little brown mushrooms' (LBMs – page 616) and the dividing line between these two groups is not well defined.

All species in the group are decomposers, and almost all degrade wood.

Other similar fungi:

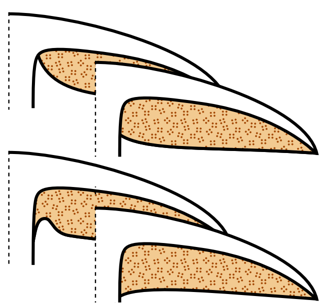
– some 'little brown mushrooms' (LBMs) grow on wood, but at most have only faintly scaly caps (page 616).

– some lignicolous brown-spored agarics are pleurotoid with excentric, lateral or missing stems. See the pleurotoids (page 60).

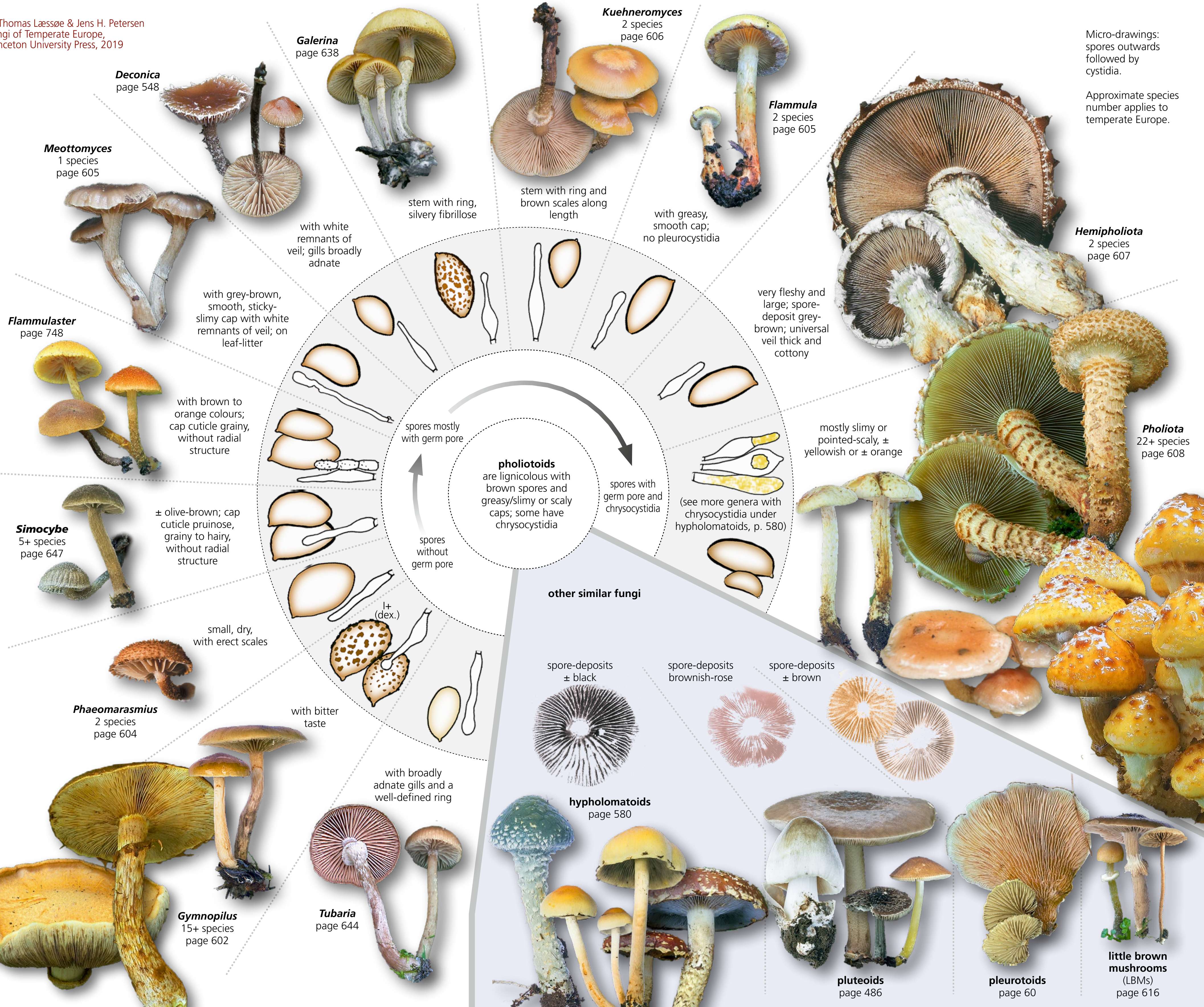
– lignicolous species with brownish-rose spore-deposits and free gills can be found under the pluteoids (p. 486).

– scaly or slimy species with dark chocolate-brown to black spore-deposits are found under the hypholomatoids (page 580).

Further reading: 112, 156, 181, 225.



adnexed to adnate, emarginate or short decurrent gills



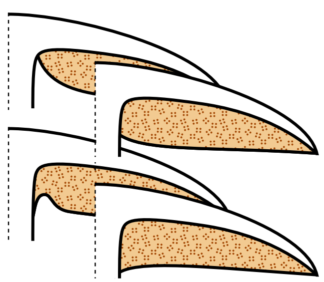
Little brown mushrooms

This group includes mostly small, predominantly brownish agarics, *e.g.* *Tubaria*, *Naucoria*, *Galerina*, *Conocybe*, *Pholiotina*, *Simocybe*, *Agrocybe* and *Flammulaster*. The label LBM that is used for this group of fungi was coined many years ago. The more vividly coloured *Bolbitius* species are also included here, and also the more fleshy *Agrocybe, Cyclocybe* and *Phaeocollybia*. The group overlaps somewhat with the pholiotids (page 600).

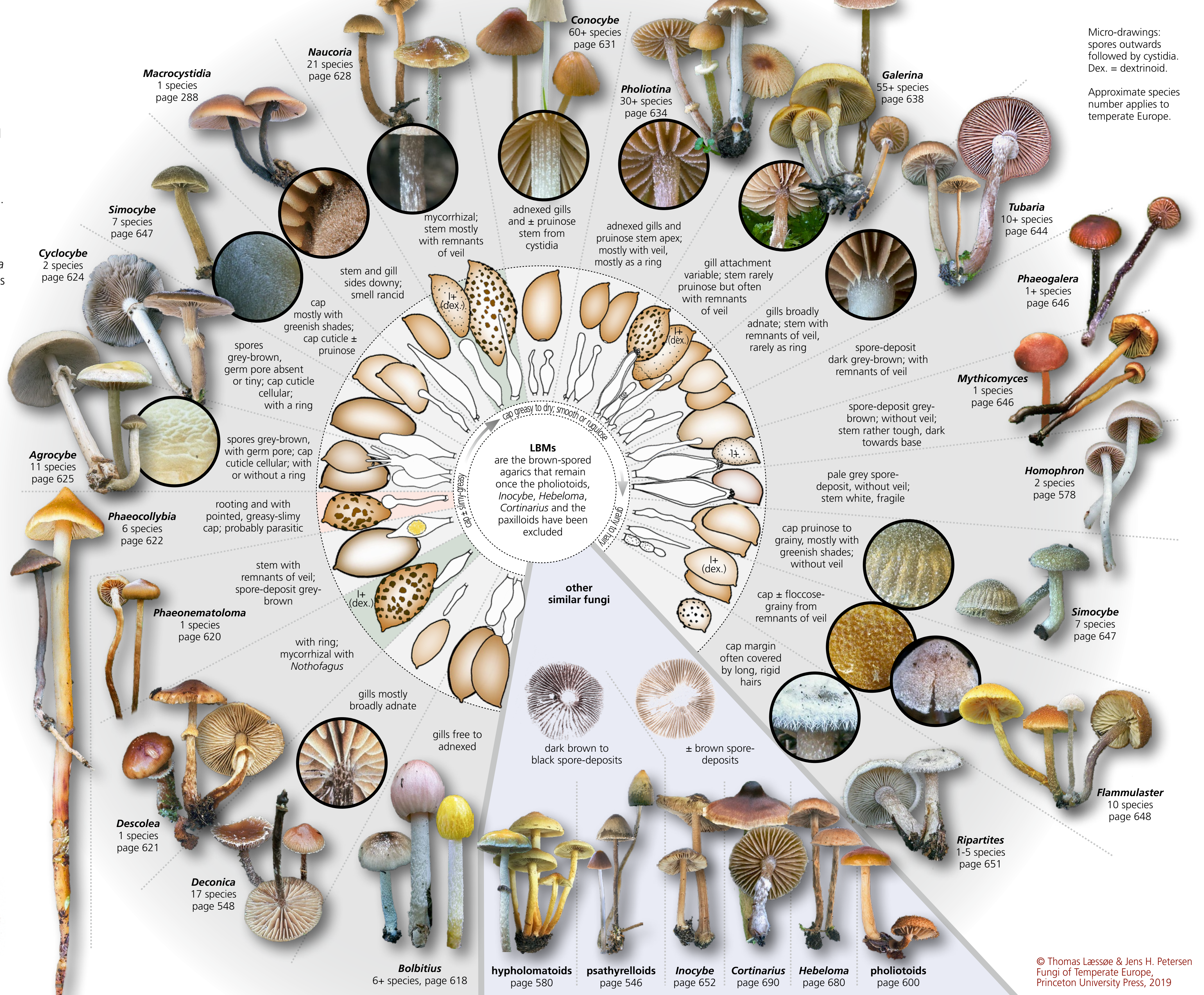
The majority of the species are decomposers but *Descolia* and *Naucoria* are ectomycorrhizal and *Phaeocollybia* is possibly a root parasite.

Other similar fungi:
– psathyrelloids and hypholomatoids have darker, purple-brown to black spores (pages 546 & 580).
– pholiotoids are mostly wood-inhabiting, larger and have slimy or scaly caps (page 600).
– *Inocybe* has mostly coarsely fibrillose cap surfaces and spermatic or strong fruity odours (page 652).
– *Hebeloma* has mostly earthy, fruity or flower-like odours (page 680).
– *Cortinarius* has mostly larger fruitbodies with red-brown spore-deposits and threadlike partial veils (page 690).

Further reading: 102, 103, 113, 113, 121, 122, 123, 156, 181, 182, 201, 227, 296, 331, 341.



free, adnexed to adnate, emarginate or short decurrent gills



Inocybe

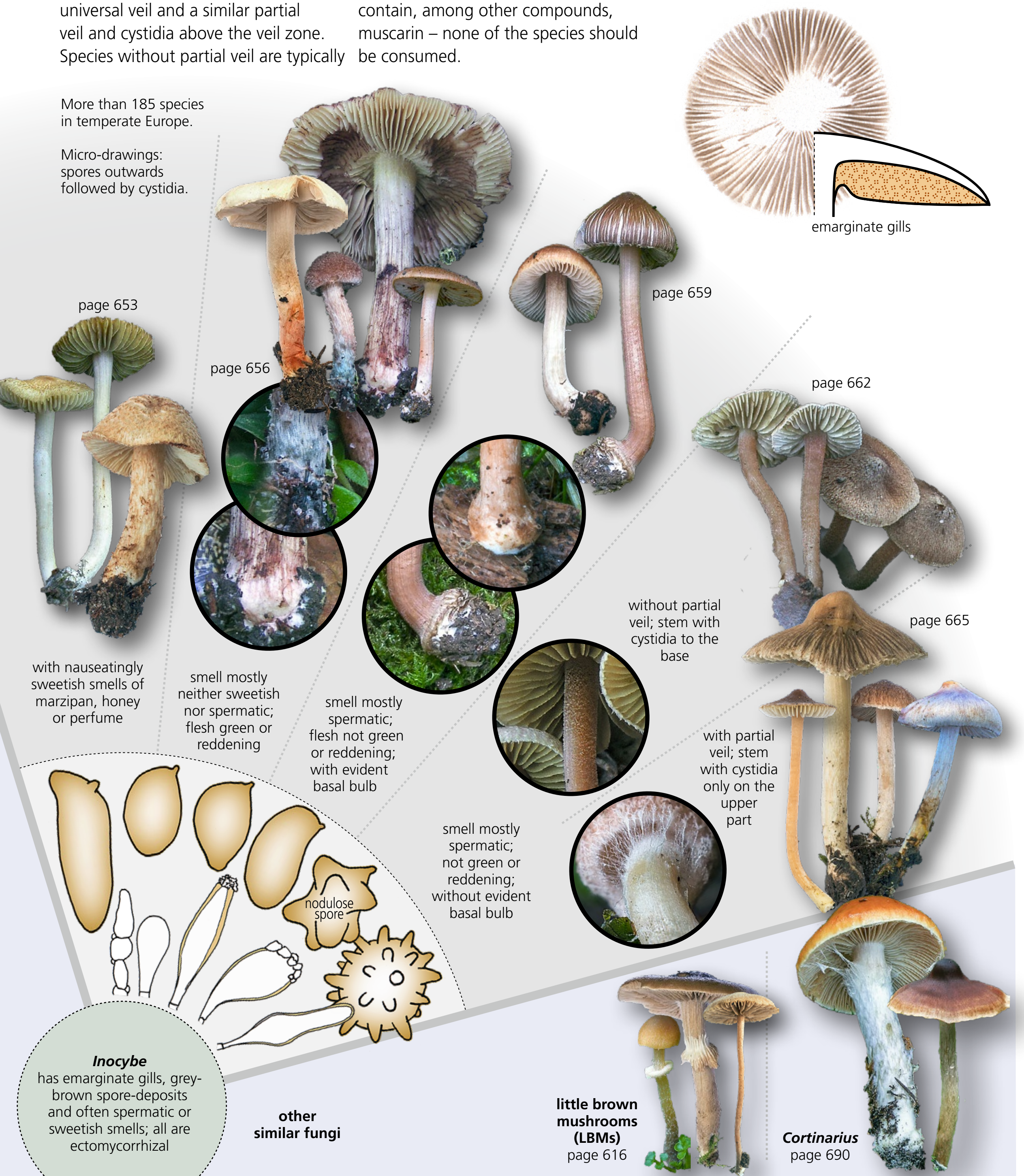
This genus includes ectomycorrhizal agarics with fibrillose to scaly caps, grey-brown spore-deposits and mostly conspicuous cystidia. Many species have spermatic or, more rarely, flower- or fruit-like, strong odours.

Inocybes may have a thread-like universal veil and a similar partial veil and cystidia above the veil zone. Species without partial veil are typically downy from cystidia along the entire lengh of the stem. Young fruitbodies with untouched stems are important when assessing these characters. The genus can be divided into subgenera based on cystidia characters.

Many species are poisonous and contain, among other compounds, muscarin – none of the species should be consumed.

Other similar fungi:
– *Cortinarius* has more rust-brown spore-deposits (page 690).
– LBMs have different odours or more rust-brown spores (page 616)

Further reading: 156, 173, 184, 315.



†?*Inocybe corydalina* is a large, pale *Inocybe* with greenish, appressed fibrous scales mostly towards the the umbonate centre. The smell is sweetish, perfume-like, nauseating. The flesh is ± reddening. The stem is pale, but darkens ± towards the base, sometimes greenish. The pleurocystidia are thick-walled (to 2 µm) with crystals on top. The spores are amygdaliform and measure 7.5–9.5 × 5–6 µm. Occurs on ± calcareous soils or clay, mostly with *Fagus* and other deciduous trees, rarely with conifers.

Other large inocybes with sweetish odours, *e.g. I. fraudans* ▷▷ and *I. bongardii* ▷▷, are not green at the cap centre, redden less obviously, or have distinct brown scales. *Inocybe erinaceomorpha* ▽, sometimes treated as a variety of *I. corydalina*, differs in having a dark brown cap centre and mostly dark brown fibrous, adpressed scales.

Widespread, occasional, absent from the boreal zone; mainly July–October.

†?*Inocybe erinaceomorpha* is a rather fleshy, cinnamon-brown, scaly-fibrous *Inocybe* with a nauseatingly strong smell of cider. The stem is ± cylindrical, at first white, later tinged in the cap colour. The flesh can redden slightly. The pleurocystidia are ± clavate with up to 2 µm wide walls. Spores, smooth, amygdaliform and measure 7.5–9.5 × 5–6 µm. Occurs on clay soils with *Fagus* and *Quercus*.

Inocybe corydalina △ has a grey-green cap centre. Other somewhat similar species have flesh that reddens strongly or thin-walled pleurocystidia.

Widespread, occasional to rather rare, absent from the boreal zone; August–October.

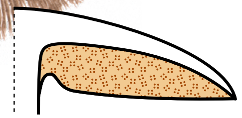
Thomas Læssøe

Hebeloma

This genus includes mycorrhizal agarics with ± grey-brown spore-depopsits, mostly smooth, greasy to slimy caps, emarginate gills and fruity, flower-like, radish-like to earth-like odours. The spores are ± verrucose and may be ± dextrinoid and have a ± loosening outer wall; the gill edge is covered with cystidia which, in some cases, produce a clear liquid that traps the dark spores.

Other similar fungi:
– *Cortinarius* may look similar, but has more rust-brown spores (page 690).
– the remaining group of brown spored mushrooms (LBMs) has different odours and mostly more rust-brown spores (page 616).

Further reading: 29, 156, 184.

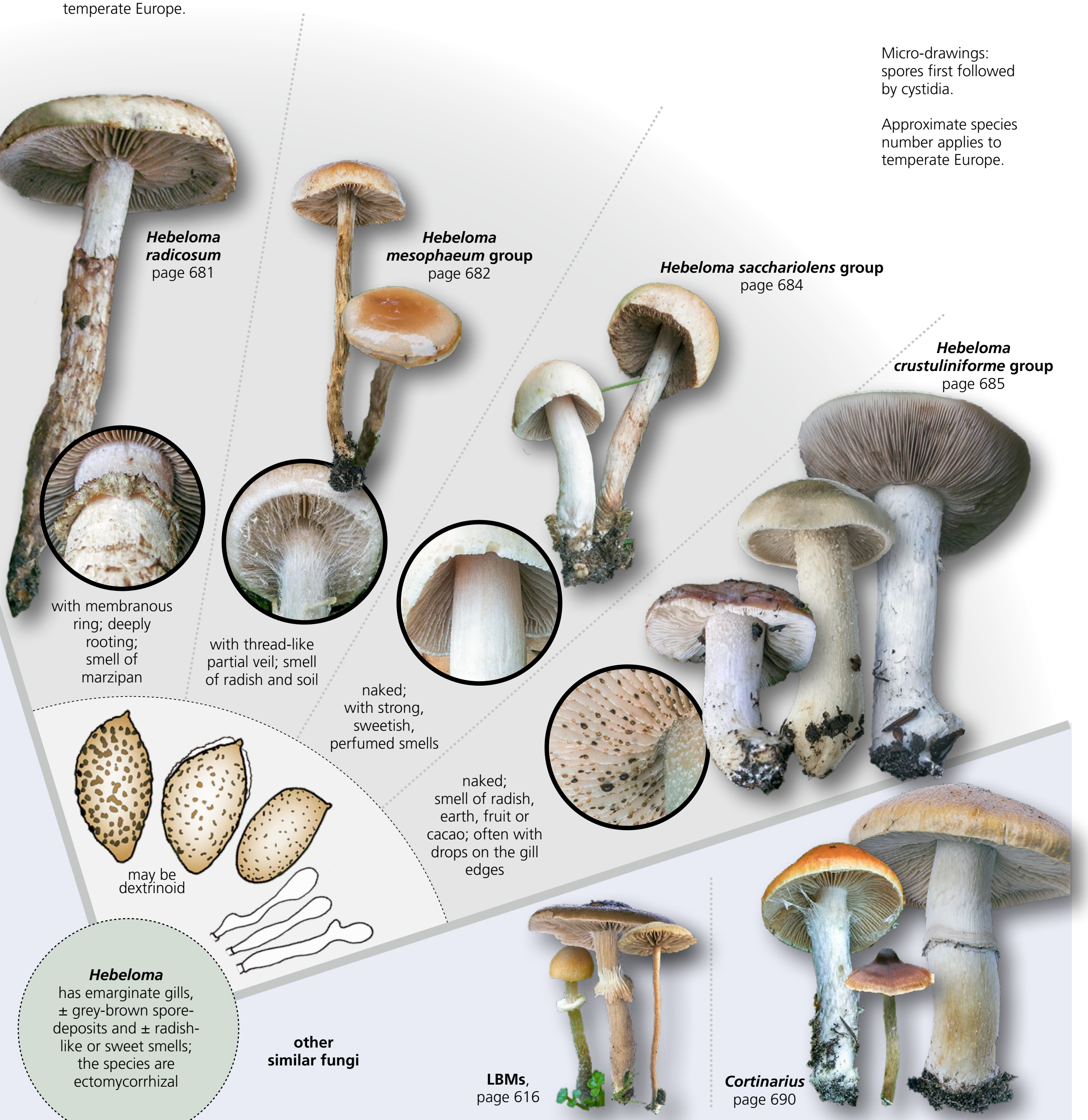


emarginate gills

More than 55 species in temperate Europe.

Micro-drawings: spores first followed by cystidia.

Approximate species number applies to temperate Europe.



Hebeloma radicosum is a very distinctive, large *Hebeloma* with a deeply rooting stem, a striking marzipan- or bitter almond-like smell and a floccose ring. The cap is dull yellowish brown to pinkish buff with scaly remnants of veil. The spores measure 8–10 × 4.5–5.5 µm. Occurs in deciduous forests, mostly with *Fagus*, appearing from latrines or middens made by moles or other small forest-dwelling mammals; a so-called ‘ammonia fungus’.

May recall some pholiotoids, particularly *Hemipholiota populnea* (page 607), but the smell, its soil-inhabiting nature with a very deeply rooting stem and ornamented spores are good separating characters.

Widespread and fairly common in the nemoral zone but becoming scarcer towards the north and absent from the boreal zone; July–November.

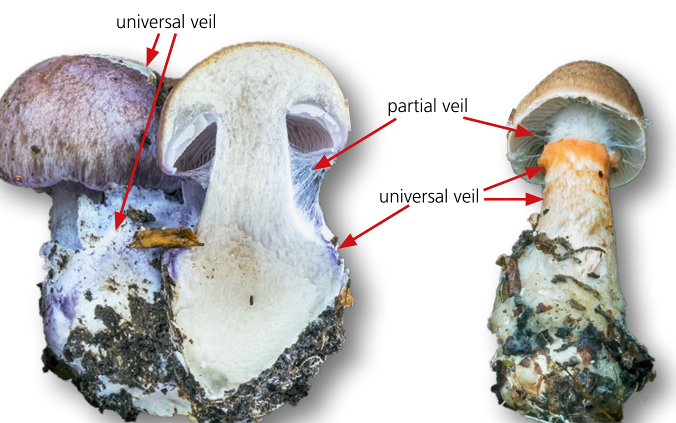
Cortinarius

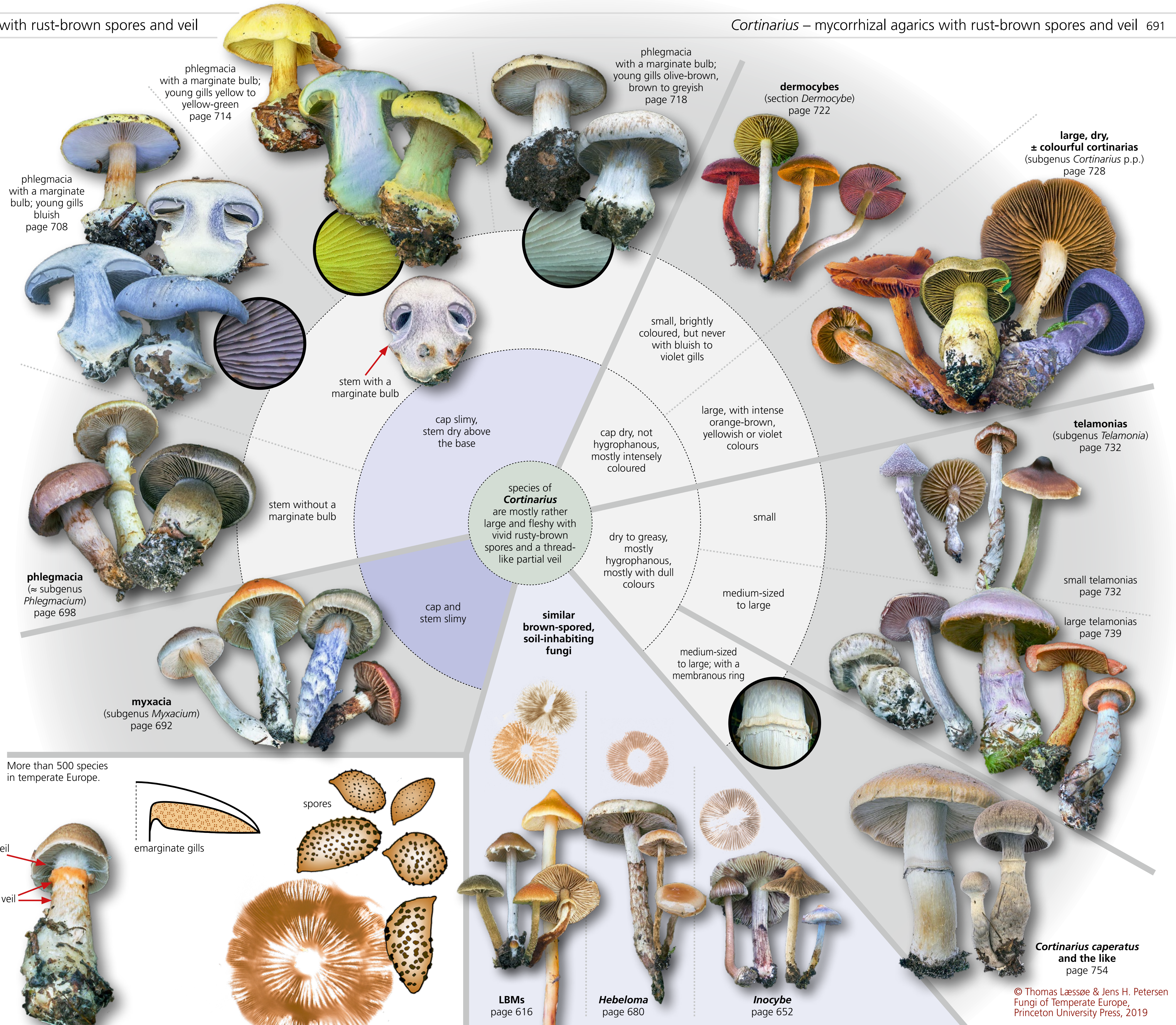
Cortinarius is a genus of ectomycorrhizal agarics with ± emarginate gills, rusty-brown, verrucose, mostly dextrinoid spores and well-defined veils. The partial veil is mostly thread-like, while the universal veil leaves a woolly, thread-like or slimy covering on the lower stem and on the cap. Only very rarely with cheilocystidia (of a simple type), and never pleurocystidia.

The genus is enormous and difficult to deal with. New species are constantly being described and new synonymies published. Safe identification is in many cases not possible without sequencing. Important macroscopical characters include the type of veil (slimy or thread-like), the gill and flesh colour when young, the overall shape, the smell, and chemical colour reactions with KOH.

Other similar fungi:
– *Inocybe* has fibrillose to coarsely fibrillose caps and grey-brown spores. The spores are smooth, nodulose or star-shaped, and all species have cystidia (page 652).
– *Hebeloma* likewise has grey-brown spores and smells mostly earth- or radish-like. The spores are verrucose and all species have prominent cystidia on the gill edge (page 680).
– little brown mushrooms (LBMs) are typically decomposers, and generally have cystidia (page 616).
– *Leucocortinarius bulbiger* recalls a white-spored phlegmacia (page 257).

Further reading: 46, 69, 124, 125, 126, 127, 156, 184, 305, 323.





Paxillus and the like

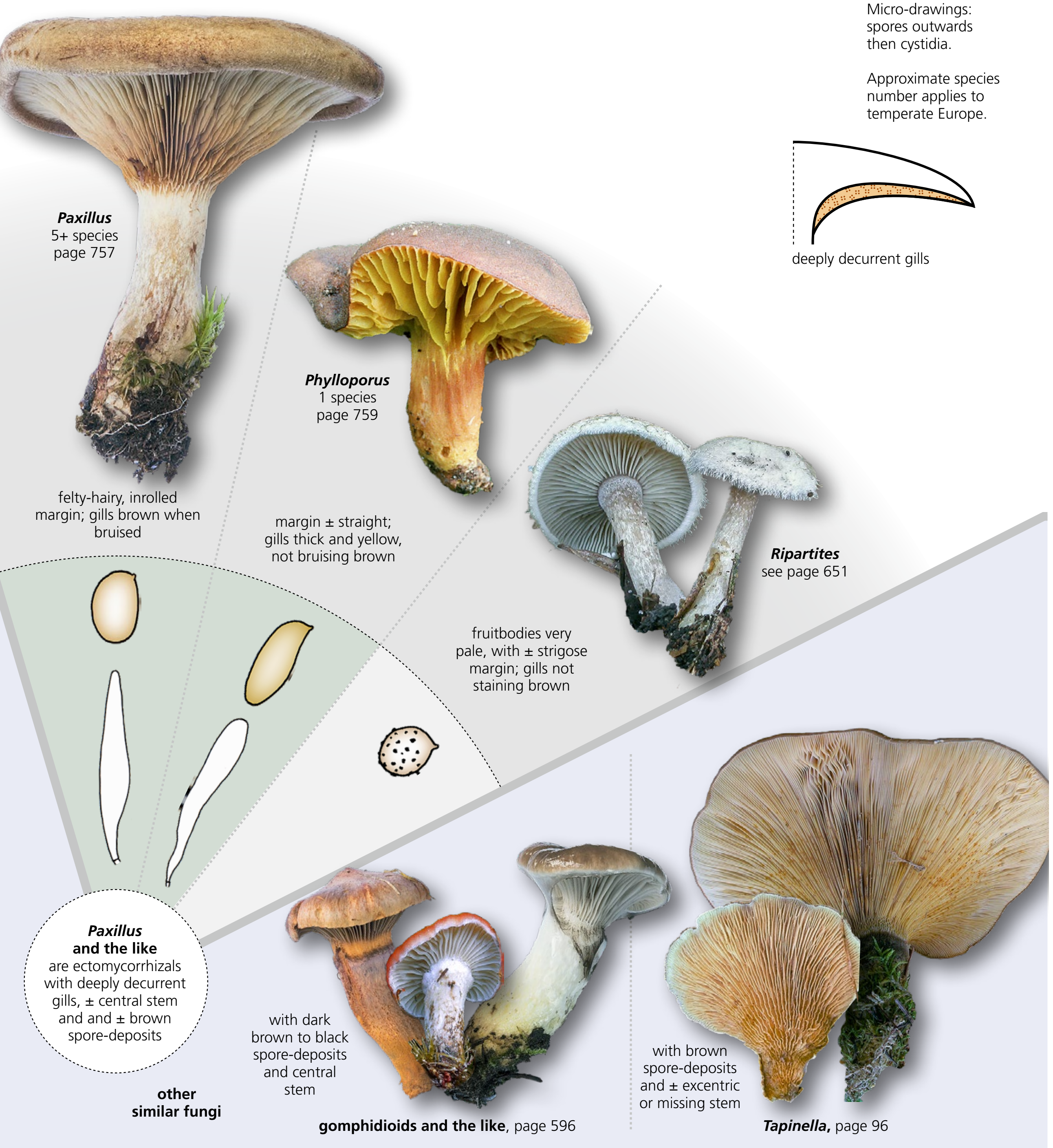
This group includes agarics with a ± brown spore-deposit, deeply decurrent gills and a ± central stem. Both of the genera included, *Paxillus* and *Phylloporus*, are ectomycorrhizal and belong phylogenetically to the *Boletales*.

Other similar fungi:
– gomphidioids have dark brown to black spore-deposits (page 596).
– the brown-spored genus *Tapinella* has ± excentric, lateral or missing stems (pleurotoids page 96).
– *Lepista* & *Paralepista* are more smooth-capped and have whitish to brownish-rose spore-deposits and verrucose spores (page 112).

Further reading: 97, 133, 333.

Micro-drawings: spores outwards then cystidia.

Approximate species number applies to temperate Europe.



Paxillus is a genus of ectomycorrhizal, brown-spored agarics with fairly crowded, decurrent gills that can be loosened from the cap flesh. The colour of a fresh spore-deposit is important for identification (although this can change over time). Repeated consumption of paxilloids may cause a life-threatening autoimmune reaction.

††***Paxillus involutus*** is a relatively slender, rather pale *Paxillus* with a downy, inrolled, wrinkled margin. The stem is ± smooth; lacks conspicuous reddish spots or yellow bands. The gills are pale straw-yellow to yellowish-brown and stain brown when bruised; they can be loosened from the pale cap flesh. The spore-deposit is yellow-brown to grey-olive. The smooth spores measure 7–11 × 5–6.5 µm. Mostly mycorrhizal with *Picea* and *Betula*, and usually on poor acidic soils.

Paxillus filamentosus ▷▷ is more yellow-fleshed and occurs with *Alnus*. Other species are shorter and thicker-stemmed.

Widespread and very common; June–November.

Boletes

The boletes is a group of fungi that form rather soft-fleshed fruitbodies that have tubes rather than gills below the cap and a sturdy central stem. The tubes are generally not joined firmly to each other, or to the cap flesh, from which the entire tube layer can easily be loosened. The spores form inside the tubes and are mostly brown. Many boletes change colour when bruised or sectioned. These colour changes, the colour of the pores (the visible part of the tubes) and the cap surface structure are very important characters.

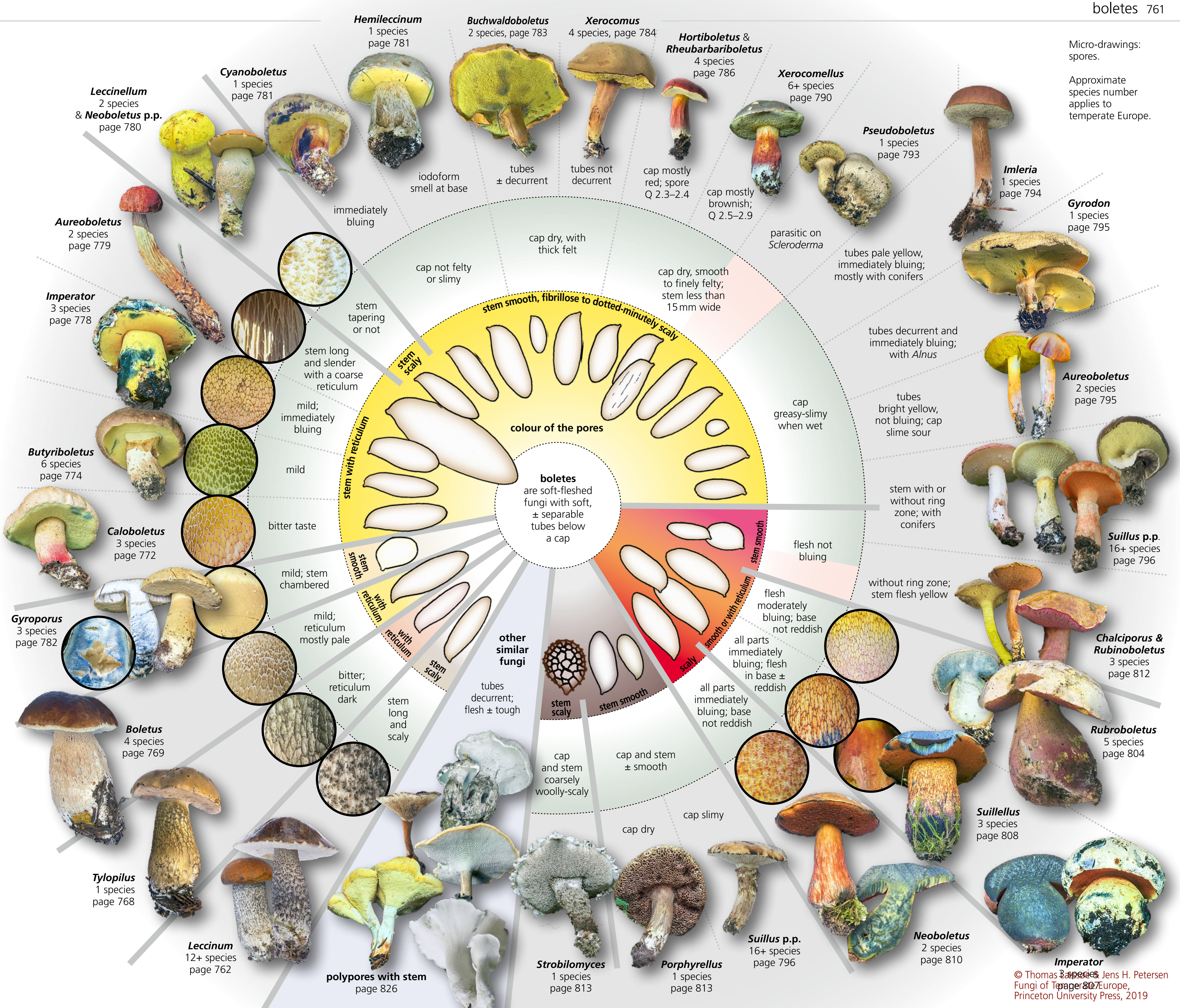
The boletes constitute a monophyletic entity and are classified in the order *Boletales*. The order also includes some false truffles (*e.g. Rhizopogon*), some corticioids (*e.g. Serpula*) and some species with gills (*e.g. Paxillus* and the gomphidioids).

Almost all boletes are ectomycorrhizal with deciduous trees or conifers. The genus and sometimes the species of the host is important for identification, especially in the genera *Leccinum* and *Suillus*. A few species are parasitic: *Pseudoboletus* parasitize *Scleroderma*; *Buchwaldoboletus* is probably parasitic on *Phaeolus;* and *Chalciporus* perhaps parasitizes *Amanita muscaria*.

There are many choice edibles among the boletes, but also a few bitter, inedible species (*e.g. Tylopilus felleus*, *Caloboletus radicans* and *C. calopus*) and most species of *Rubroboletus* and *Imperator* are moderately poisonous.

Other similar fungi:
– polypores with a stem (*e.g. Albatrellus* and *Boletellus*) may look very similar. They have tubes that are firmly joined – both with each other and the flesh. They also often have decurrent tubes and tough flesh – see page 826.

Further reading: 71, 150, 156, 170, 194, 205, 228.



Micro-drawings: spores.

Approximate species number applies to temperate Europe.

Polypores

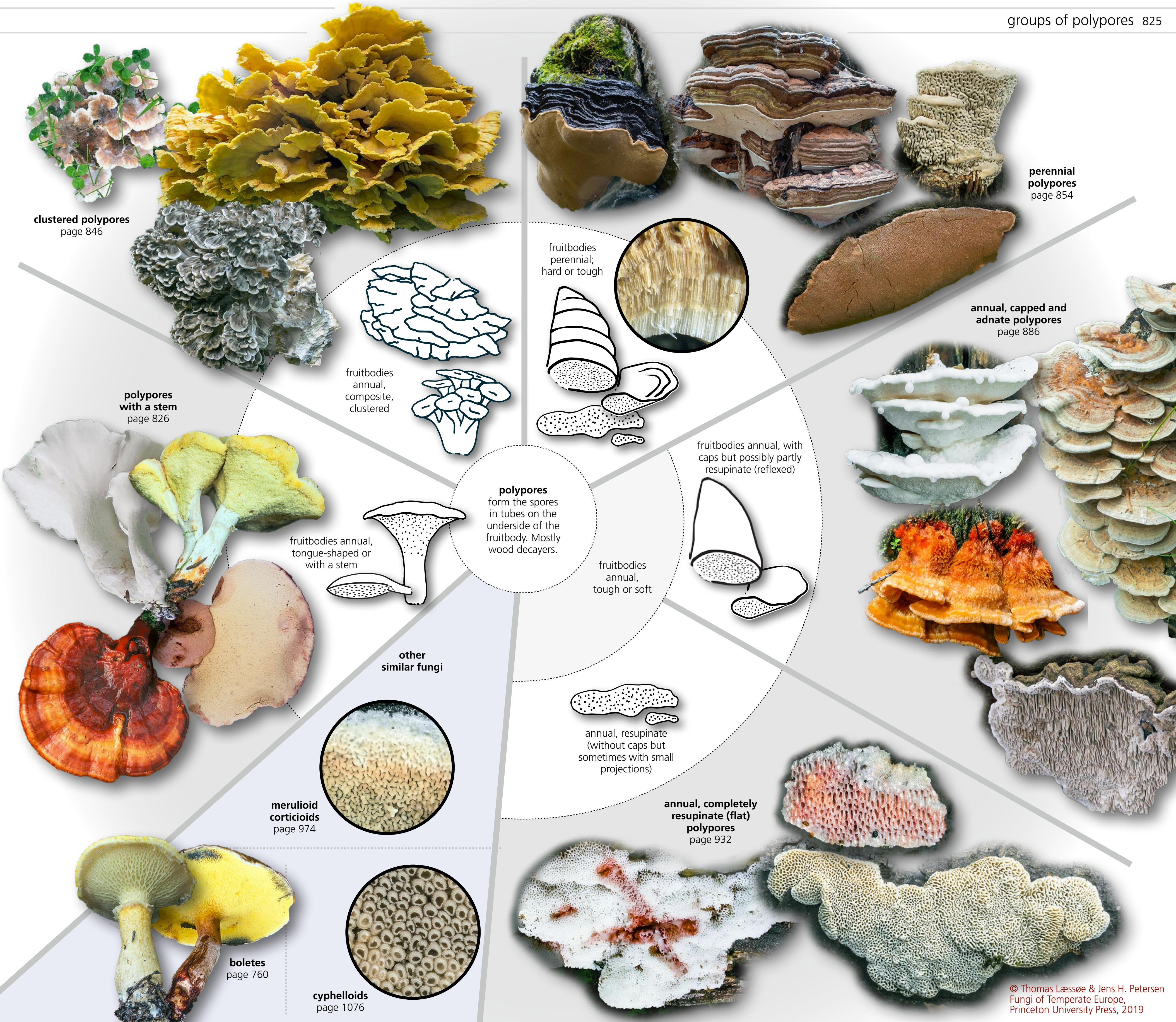
The polypores is a form group that is characterized by a tubular hymenophore where the spores are formed on a hymenium inside the downwards-pointing tubes. The tubes are normally inseparable from each other and from the cap flesh. The pores (tube mouths) may be spherical, angular, stretched, labyrinthine or gill-like. The number of pores per millimetre is an important character, best measured with a translucent ruler using a lens. The pore edges are sterile. Fruitbodies can be completely appresed to the substrate or have ± well-developed caps, and rarely also stems; they may be soft and annual or tough to hard, and in some cases perennial. Perennial fruitbodies may be recognized by typically having several tube layers and broad growth zones on the caps.

All polypores belong to *Basidiomycota* and have one-celled basidia. The only exception is *Aporpium* (page 1186), which belongs to the jelly fungi and has longitudinally divided basidia. Most species with tough or hard fruitbodies have a complicated hyphal structure, which, besides the normal generative hyphae, consists of branched binding hyphae and/or skeletal hyphae (page 35). Fruitbodies with two hyphal types are termed dimitic, and those with three are referred to as trimitic.

Almost all polypores are decomposers and typically occur on wood. They produce a brown rot or a white rot (page 14). A few species are ectomycorrhizal, *e.g. Albatrellus* & *Scutiger* (page 828) and *Coltricia* (page 843).

Other similar fungi:
– the boletes are always soft-fleshed, and their tubes are not well-joined and can be loosened from the cap flesh; most are mycorrhizal (page 760).
– merulioid corticioids have a ± folded hymenophore where also the edges are covered with hymenium (page 974).
– cyphelloids are small, cup-shaped *Basidiomycota*. They may occur in dense groups and mimic a polypore (page 1076).

Further reading: 17, 37, 161, 163, 193, 219, 220, 235, 282, 283, 308, 309, 339, 356, 366, 367.



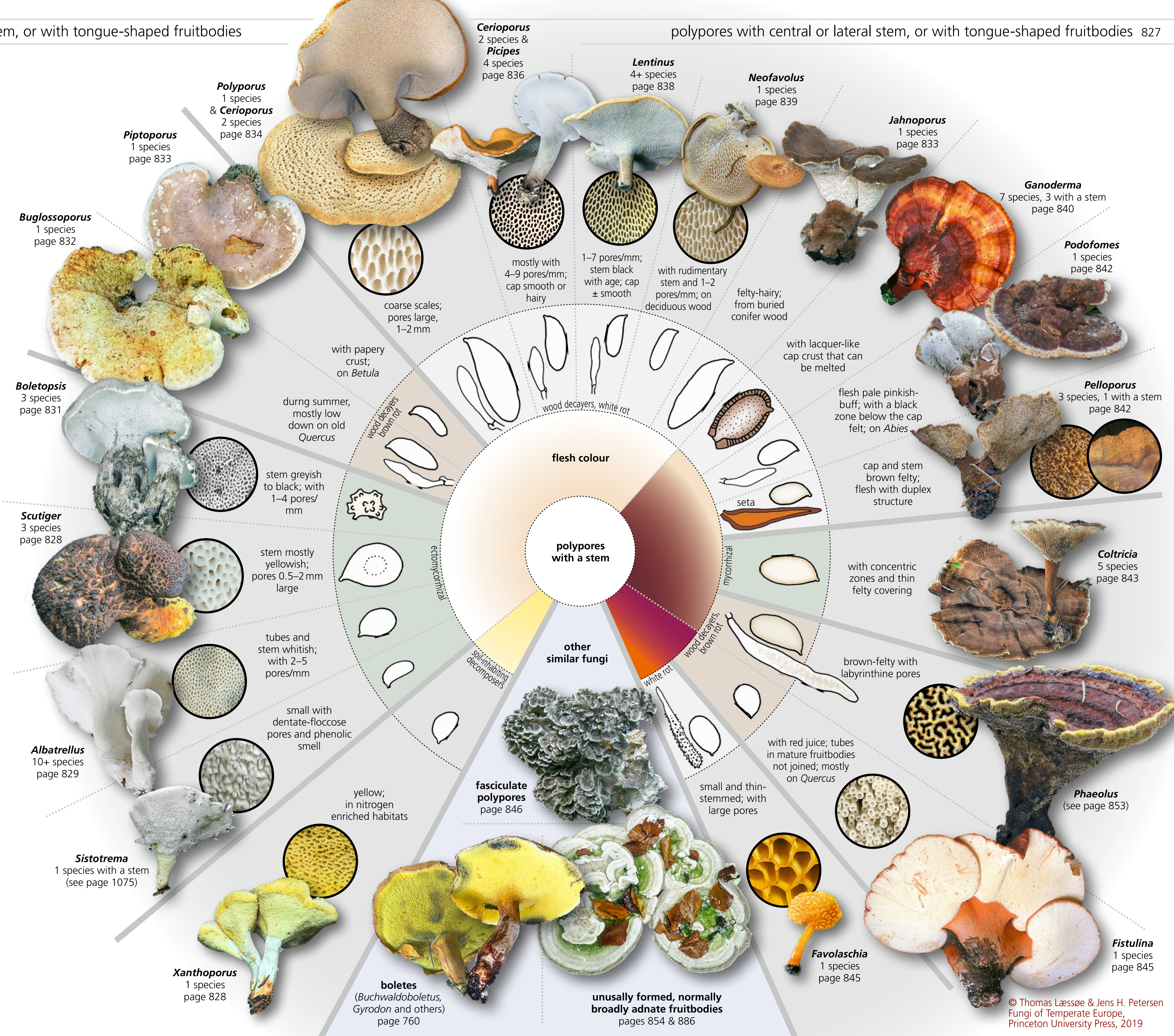
Polypores with a stem

This form group includes somewhat boletoid fruitbodies and more tongue-shaped fruitbodies, that may have a short lateral stem. All form annual fruitbodies. In one genus, *Fistulina*, the tubes are not joined. Most species produce hyaline, smooth spores, but a few have brown, ornamented spores. Prominent brown setae are found in one genus.

The group includes both ectomycorrhizals, *e.g. Albatrellus*, *Scutiger* and *Coltricia*, decomposers on soil, *e.g. Xanthoporus*, and wood decayers that produce a white or brown rot.

OTHER SIMILAR FUNGI:
– boletes with decurrent tubes are soft-fleshed, and usually have tubes that are easy to loosen from the cap flesh. *Gyrodon* has firmly attached tubes, but these stain blue when bruised (pages 760 & 795).
– in clustered polypores the individual caps may also have a stem (page 846).
– broadly adnate polypores on top of stumps and trunks may develop a contracted base and thus recall polypores with a stem, but usually there will be more normal fruitbodies in the same fructification (pages 854 & 886).

See also the overview and the references to further reading on page 824.



Micro-drawings: spores, cystidia and setae.

Approximate species number applies to temperate Europe.

Clustered polypores

This group includes species with numerous caps from a narrow, common base or from a thick, short stem. All species in the group form annual, rather soft-fleshed fruitbodies and are typically decomposing parasites on trees.

A number of these species are prized edibles, *e.g. Grifola*, *Cladomeris umbellatus* and *Laetiporus*, and less so *Meripilus* and *Fistulina*. *Phaeolus* is used for dyeing wool. *Laetipours* is known to cause mild poisoning when cooked insufficiently.

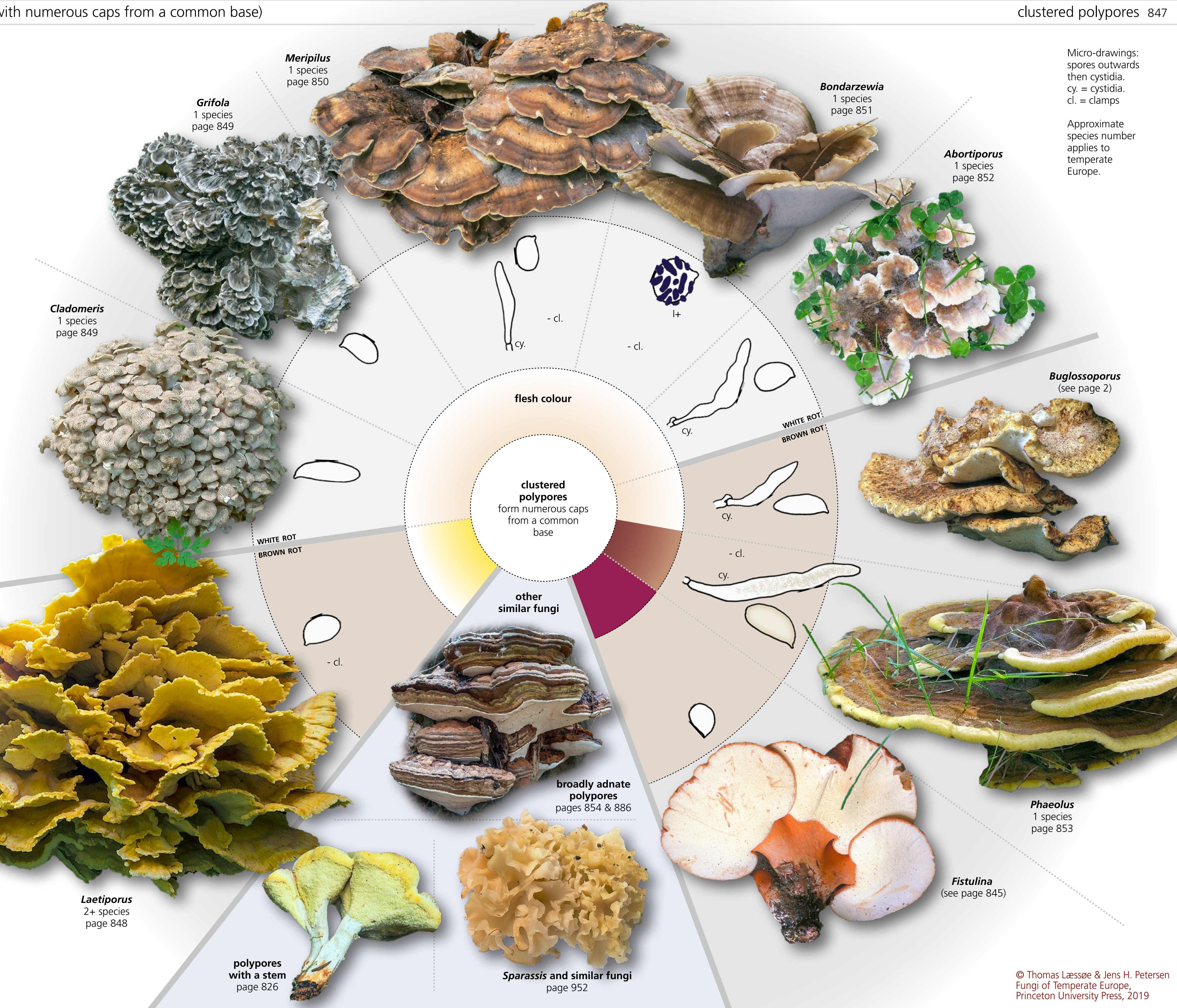
Other similar fungi:

– polypores with stems are similar, but only have one or a few caps (page 826).

– perennial, broadly adnate polypores may form numerous, layered caps, but do not have a common stem or constricted base (pages 854 & 886).

– *Sparassis* and similar fungi lack pores (page 952).

See also the overview and the references to further reading on page 824.



Perennial polypores

All polypores where the fruitbodies continue to produce new tube layers in successive years belong here. The growth periods can often be seen as raised concentric zones on the caps. The group includes most polypores with hard fruitbodies. In general, the fruitbodies have one growth period per year, but *Fomes fomentarius* has two growth periods: a strong one in the spring and a weaker one the autumn; this creates two zones of growth per year.

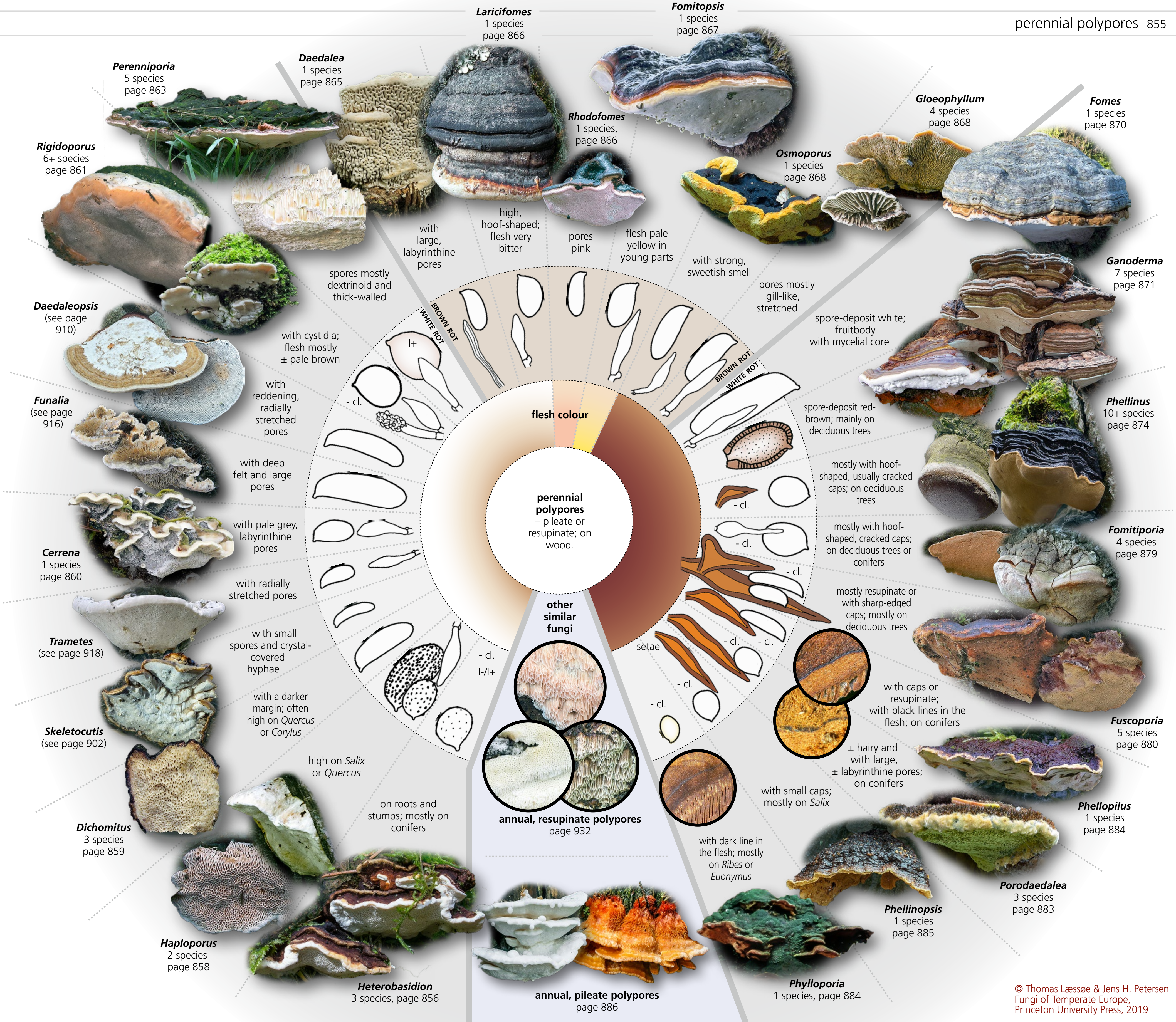
Some species are borderline perennial. For example, species of *Trametes*, *Cerrena* and *Antrodia* may, during a mild spring, continue to grow and thus produce two-layered fruitbodies. However, these fruitbodies typically rot away during the summer.

Most perennial polypores have a complicated hyphal system with both generative hyphae with septa, and branched binding hyphae and/or thick-walled skeletal hyphae without septa (page 35).

The species can be divided into white- and brown-rotters; although the two types may look surprisingly similar, they are not closely related.

OTHER SIMILAR FUNGI:
– similar but annual species of polypore are divided into two groups: those with caps (pileate) and those without (resupinate) (pages 886 & 932).

See also the overview and the references to further reading on page 824.



Micro-drawings: spores outwards, followed on the inside by cystidia and setae.
cl. = clamps.

Approximate species number applies to temperate Europe.

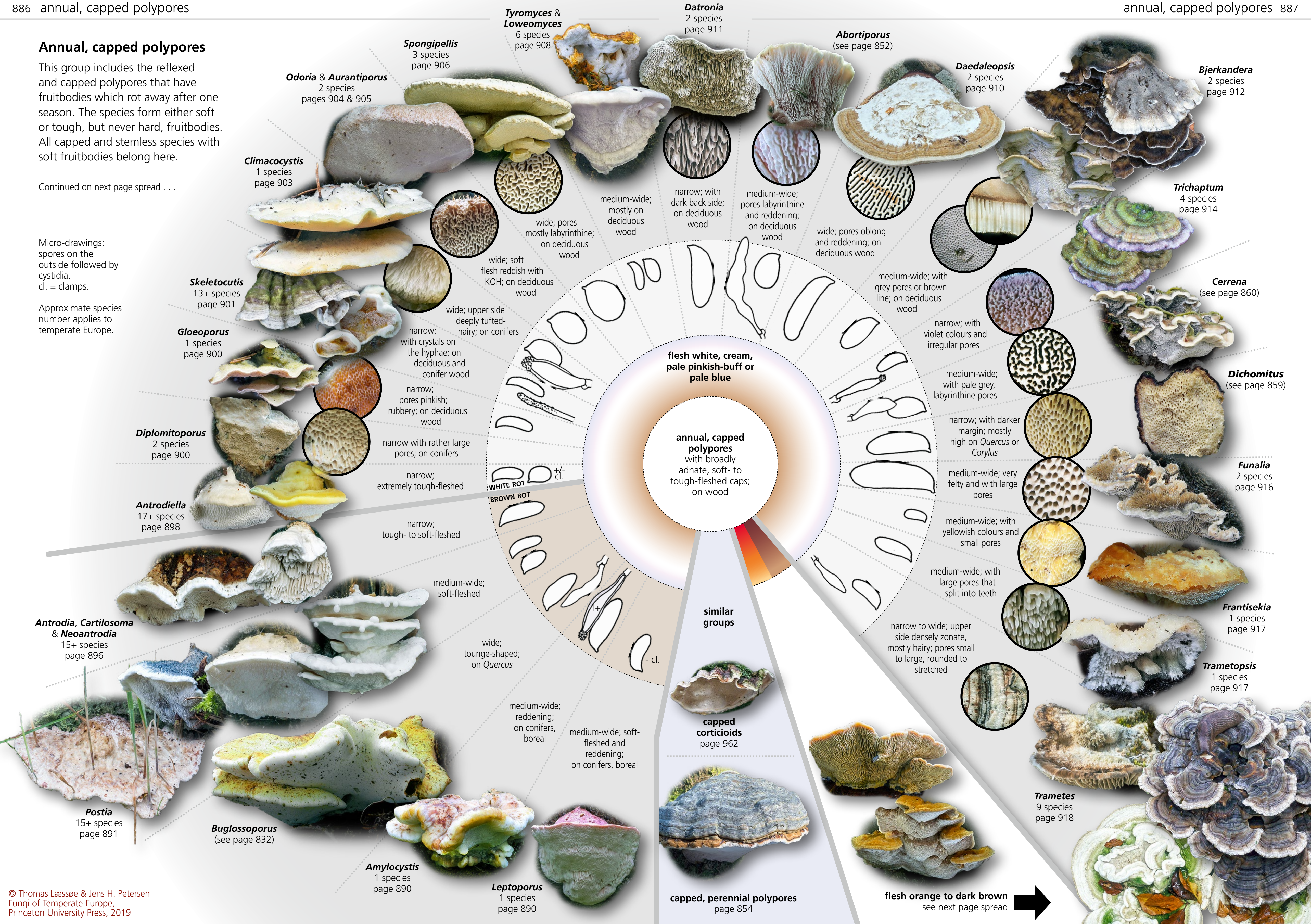
Annual, capped polypores

This group includes the reflexed and capped polypores that have fruitbodies which rot away after one season. The species form either soft or tough, but never hard, fruitbodies. All capped and stemless species with soft fruitbodies belong here.

Continued on next page spread . . .

Micro-drawings: spores on the outside followed by cystidia. cl. = clamps.

Approximate species number applies to temperate Europe.



Annual, capped polypores

continued from previous page spread . . .

Some annual polypores may consist solely of generative hyphae and are termed monomitic; such fruitbodies are typically soft and easy to break. When either skeletal hyphae or binding hyphae are also present the fruitbodies are termed dimitic; if all three hyphal types are present they are termed trimitic. Dimitic and trimitic annual fruitbodies are typically tough and leathery. (See page 35 for more on hyphal systems)

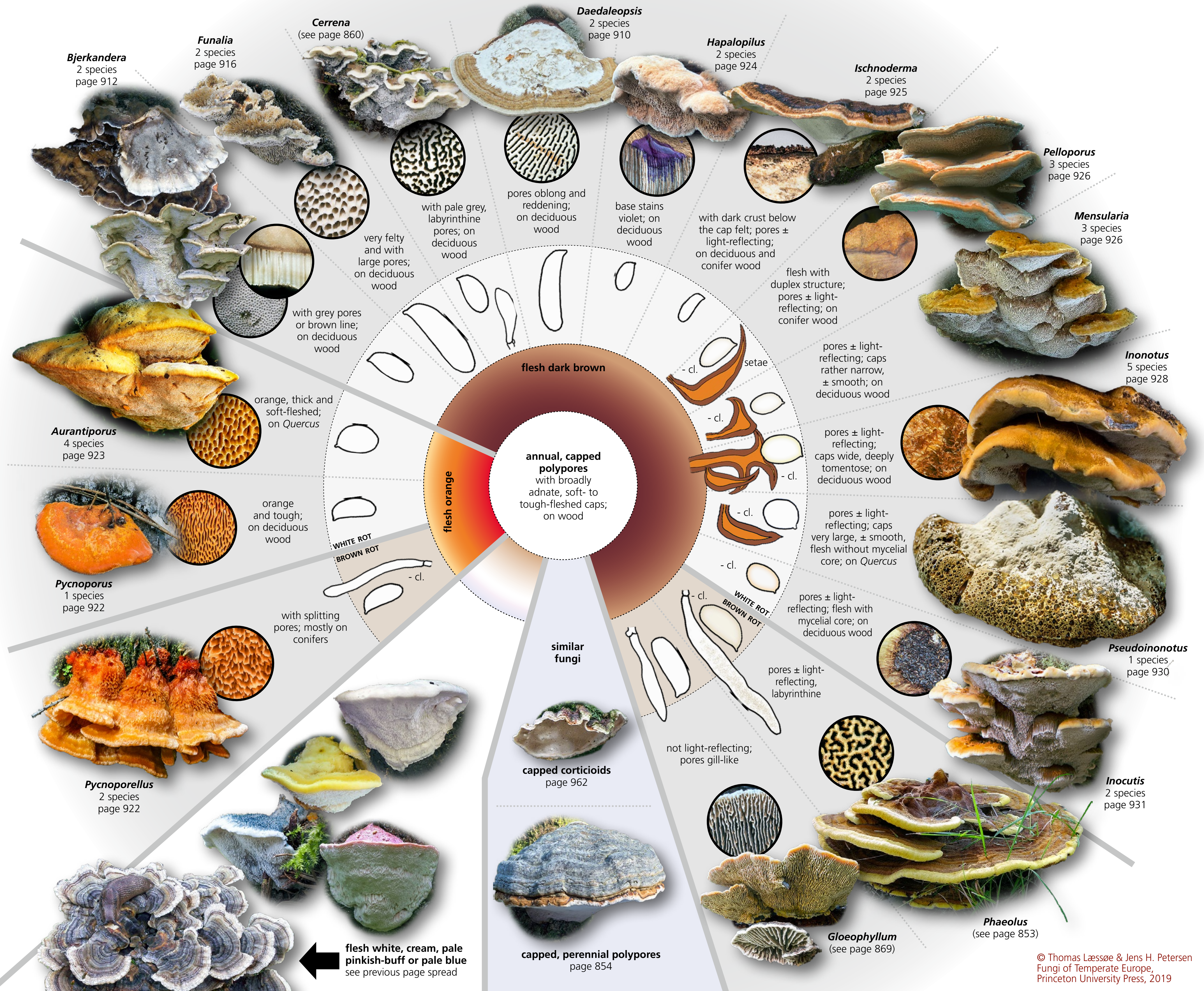
Other similar fungi:

– capped, broadly adnate, perennial polypores over time form several layers of tubes. They also often have raised zones on the surface (page 854).

– clustered polypores are annual and form numerous caps from a common stem (page 846).

– capped corticioids do not have pores; a hand lens is required (page 962).

See also the overview and the references to further reading on page 824.



Micro-drawings: spores outermost, followed by cystidia or setae. cl. = clamps.

Approximate species number applies to temperate Europe.

Annual, resupinate polypores

This group includes polypores with annual, flat fruitbodies that completely lack caps. Some species may, however, form small protuberances (false caps) without an evident cap surface. Although some species can be recognized in the field, it is a very difficult group to identify, and in most cases correct identification requires microscopy. Many species have tough, long-lasting fruitbodies that persist long after spore production has ceased.

Sterile material is easily sampled but cannot be identified. It may be a good idea to check if the specimen is able to deposit spores on a coverslip or microscope slide. Keep the specimen moist in order to enhance the chance of obtaining a good spore-deposit.

All species are wood-degrading and most produce a white rot.

Other similar fungi:

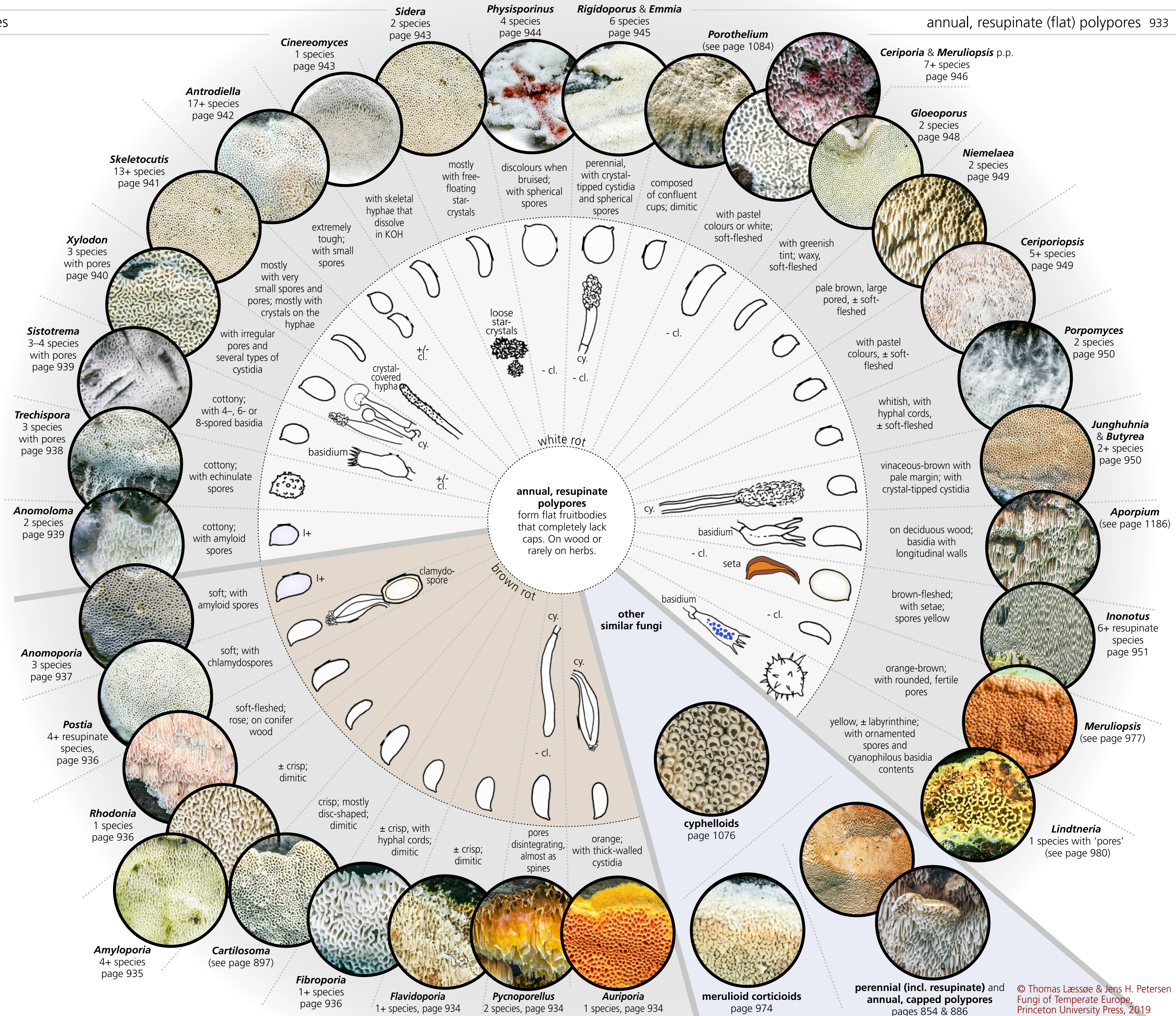
– annual reflexed (polypores with a resupinate decurrent lower part) and capped polypores (page 886).

– perennial, resupinate polypores (page 854).

– merulioid corticioids (corticioids with wrinkled-veined hymenophore) may look similar but the 'pores' are rounded and have fertile pore mouths – in true polypores the pore mouths are sterile (page 974).

– gregarious cyphelloids may recall resupinate polypores (page 1076).

See also the overview and the references to further reading on page 824.



Micro-drawings: spores first, followed on the inside by cystidia.
cl. = clamps.
cy. = cystidia.

Approximate species number applies to temperate Europe.

Rosette-fungi and the like

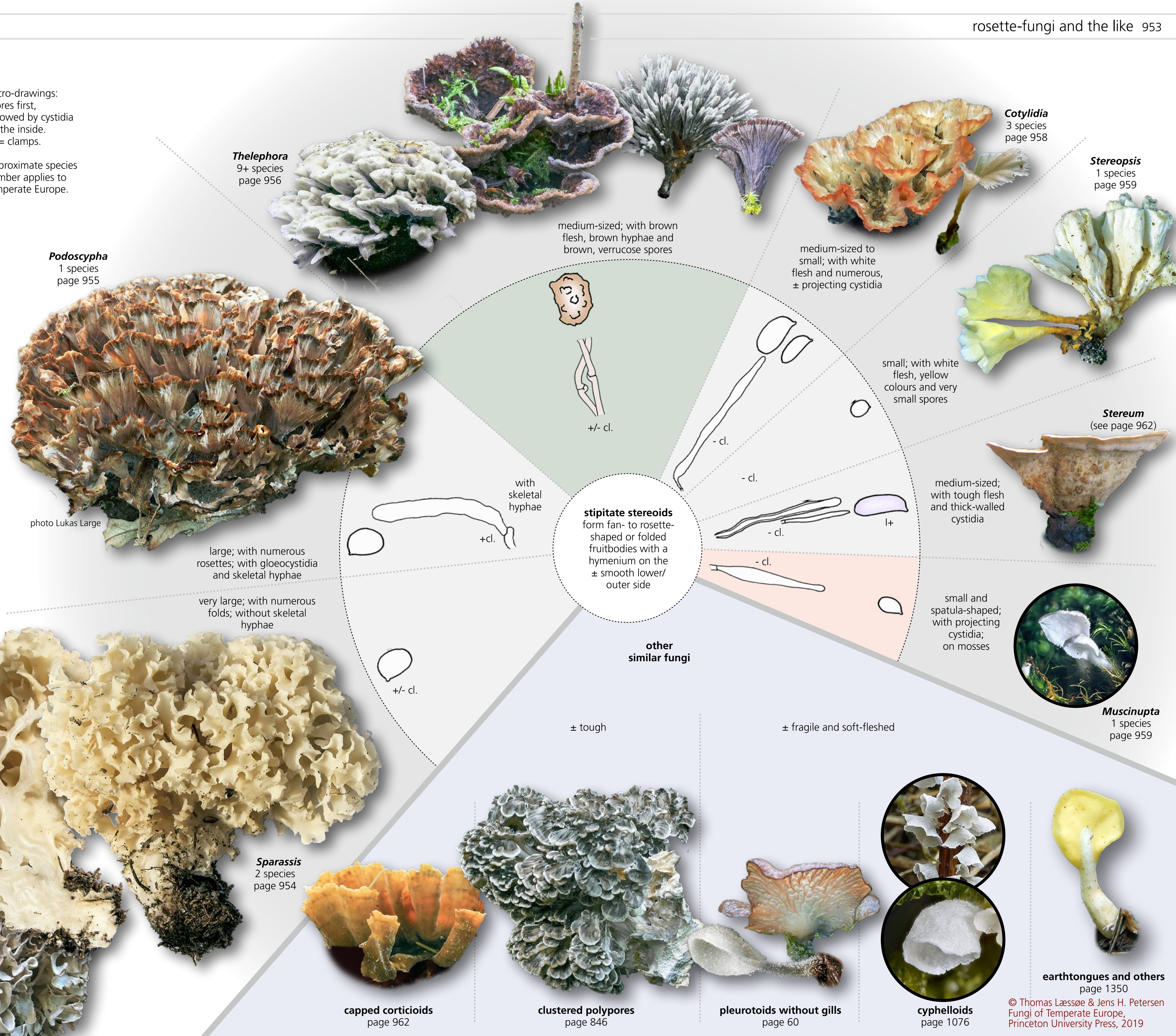
This form group comprises species that, although not closely related, are collectively known as 'stipitate stereoids'. All the species in this group produce fan- to rosette-shaped or folded fruitbodies with a ± smooth hymenium on the under/outer side. The upper/inner side is mostly sterile. The fruitbodies are typically rather tough and range from very large in *Sparassis* to small in *Muscinupta*. Species of *Thelephora* form ectomycorrhiza, while the remaining species are presumed to be decomposers or moss parasites.

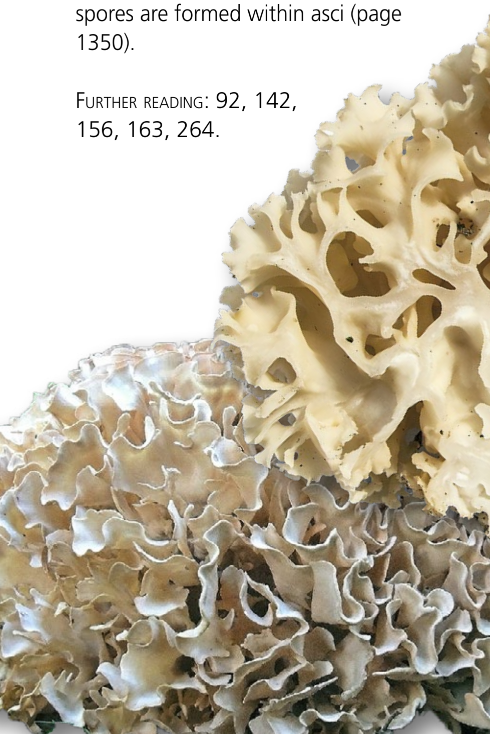
Other similar fungi:
– the clustered polypores may form large, rosette-shaped fruitbodies but they always have pores on the underside (page 846).
– capped stereoids are tough, mostly broadly attached to the substrate, and not stipitate (page 962).
– pleurotoids with reduced gills (*e.g.* *Gloiocephala* and *Arrhenia*) form soft-fleshed fruitbodies that usually have a veined hymenophore (page 60).
– cyphelloids do not normally form stems (page 1076).
– flattened, clavate species of *Ascomycota* are soft-fleshed with a hymenium on both sides and the spores are formed within asci (page 1350).

Further reading: 92, 142, 156, 163, 264.

Micro-drawings: spores first, followed by cystidia on the inside. cl. = clamps.

Approximate species number applies to temperate Europe.





Corticioids

This form group includes species with resupinate (flat) or reflexed (flat with a narrow protruding cap) fruitbodies and with a smooth, warty, spiny, toothed or veined hymenophore. Species with divided basidia or with spores that germinate with a replicate spore are shown on this wheel, but are treated with the resupinate jelly fungi (page 1162).

Some distinctive species can be told by macroscopical means. Colour, shape (mainly of the hymenophore) and ecology are the most important characters. The majority of the species, however, require microscopical study in order to reach an identification.

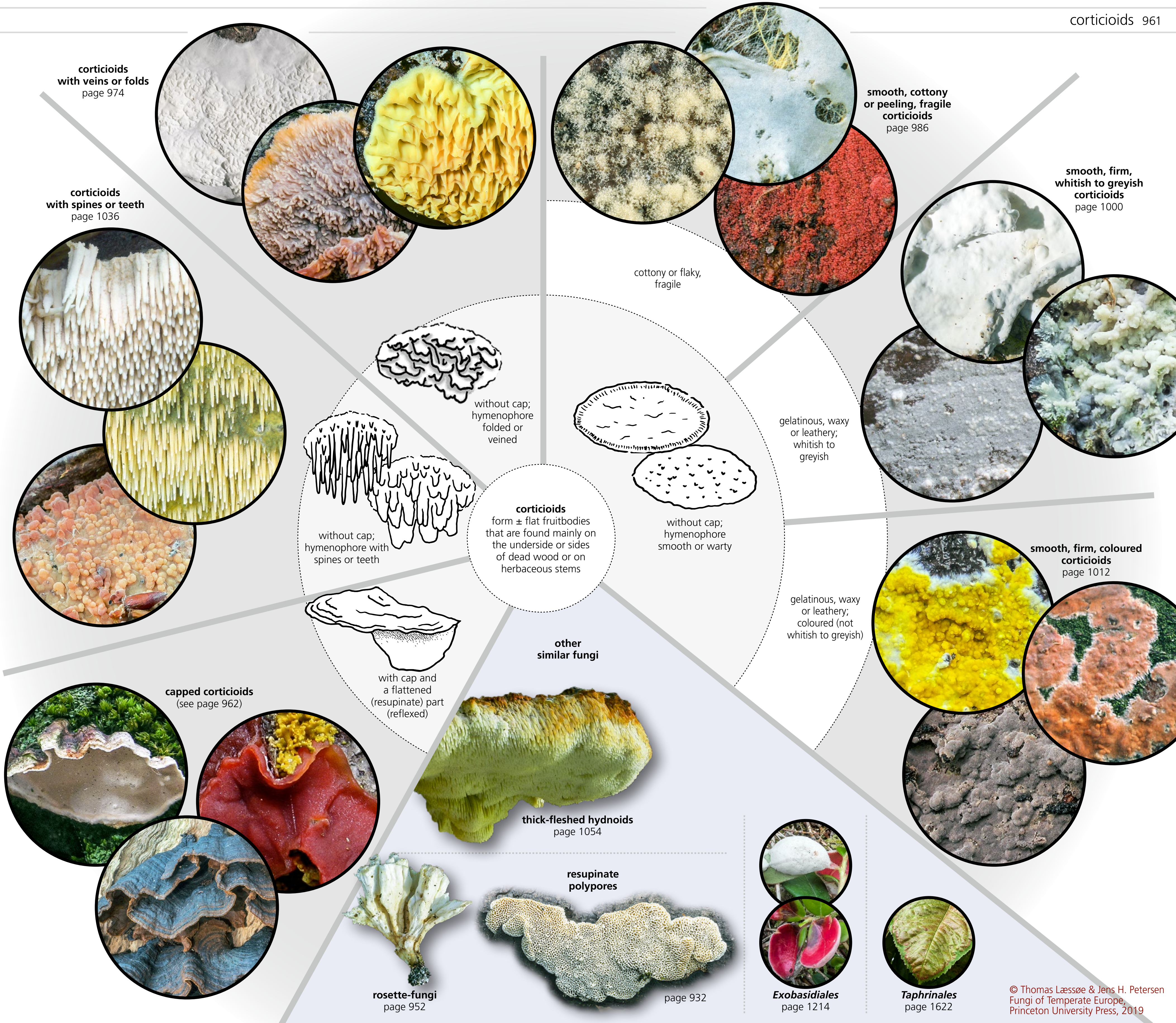
Phylogenetically the species are distributed among a series of orders that include fungi with completely different morphologies (boletes, agarics, polypores, *etc.*).

Most corticioids are decomposers, and the majority are white-rotters. Species in the *Boletales* (*e.g. Serpula* (page 984) and *Coniophora* (page 1034) produce a brown rot, and most members of the *Thelephorales*, *e.g. Tomentella* (page 998), are ectomycorrhizal. A handful of genera in other orders are also mycorrhizal.

The corticioid fungi is a large group with about 500 species in temperate Europe. Many rare or inconspicuous species are not included here, but representatives of most of the genera that occur in the area are included.

Other similar fungi:
– the rosette fungi have spathulate, cauliflower to rosette-shaped fruitbodies, with or without a ± well developed stem (page 952).
– thick-fleshed, resupinate hydnoids are treated on page 1054.
– resupinate polypores with labyrinthine pores have sterile pore margins (page 932).
– plant parasites on living stems and leaves, see *Exobasidiales* (page 1214) and *Taphrinales* (page 1622).

Further reading: 36, 50, 67, 74, 75, 81, 99, 159, 163, 339.



Capped corticioids

This form group includes capped (reflexed/stereoid) corticioids with a smooth hymenophore. Capped genera with a wrinkled or echinulate hymenophore are shown in the blue part of the wheel and are treated under merulioid corticioids (page 974) and echinulate corticioids (page 1036).

Many species in this group have caps with colours, hairs and other useful characters. With experience quite a few can be recognized without the use of a microscope. All capped corticioids may start out without a cap, so always look for older fruitbodies. Phylogenetically the species are distributed in a number of groups that are not closely related, including orders dominated by corticioid, poroid or lamellate species.

Most capped corticioids are decomposers and form a white rot. *Serpula* (page 985), *Pseudomerulius* (page 981) and *Veluticeps* (page 967) are brown-rotters and species in the genus *Thelephora* (page 956) form ectomycorrhiza.

Other similar fungi:

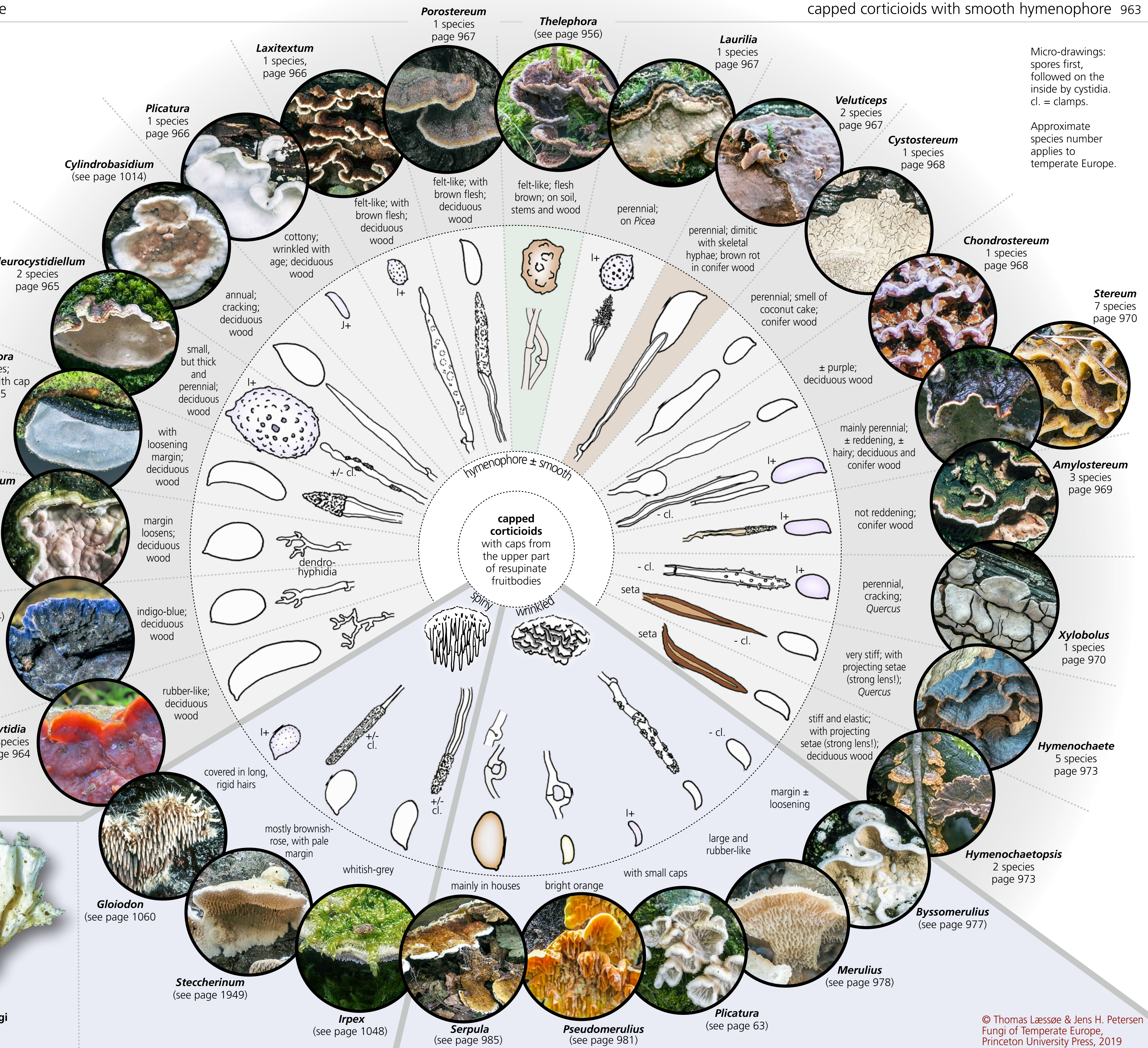
– annual, capped polypores always have proper pores on the underside of the caps (check with a hand lens) (page 886).

– rosette-fungi either have a stem or narrow towards the base (page 952).

See also the overview and the references to further reading on page 960.

Micro-drawings: spores first, followed on the inside by cystidia. cl. = clamps.

Approximate species number applies to temperate Europe.



other similar fungi

annual, capped polypores
page 886

rosette-fungi
page 960

Merulioid corticioids

This form group includes species with resupinate and reflexed fruitbodies that have a wrinkled or veined hymenophore. All such species were once included in the genus *Merulius*.

Some merulioid corticioids are very distinctive and can easily be recognized without the aid of a microscope, while others, *e.g.* species in *Leucogyrophana*, *Serpula* & *Pseudomerulius* are very difficult to separate without using micro-characters. The majority are white-rotters, but species related to the dry rot fungus *Serpula lacrymans* produce brown rots.

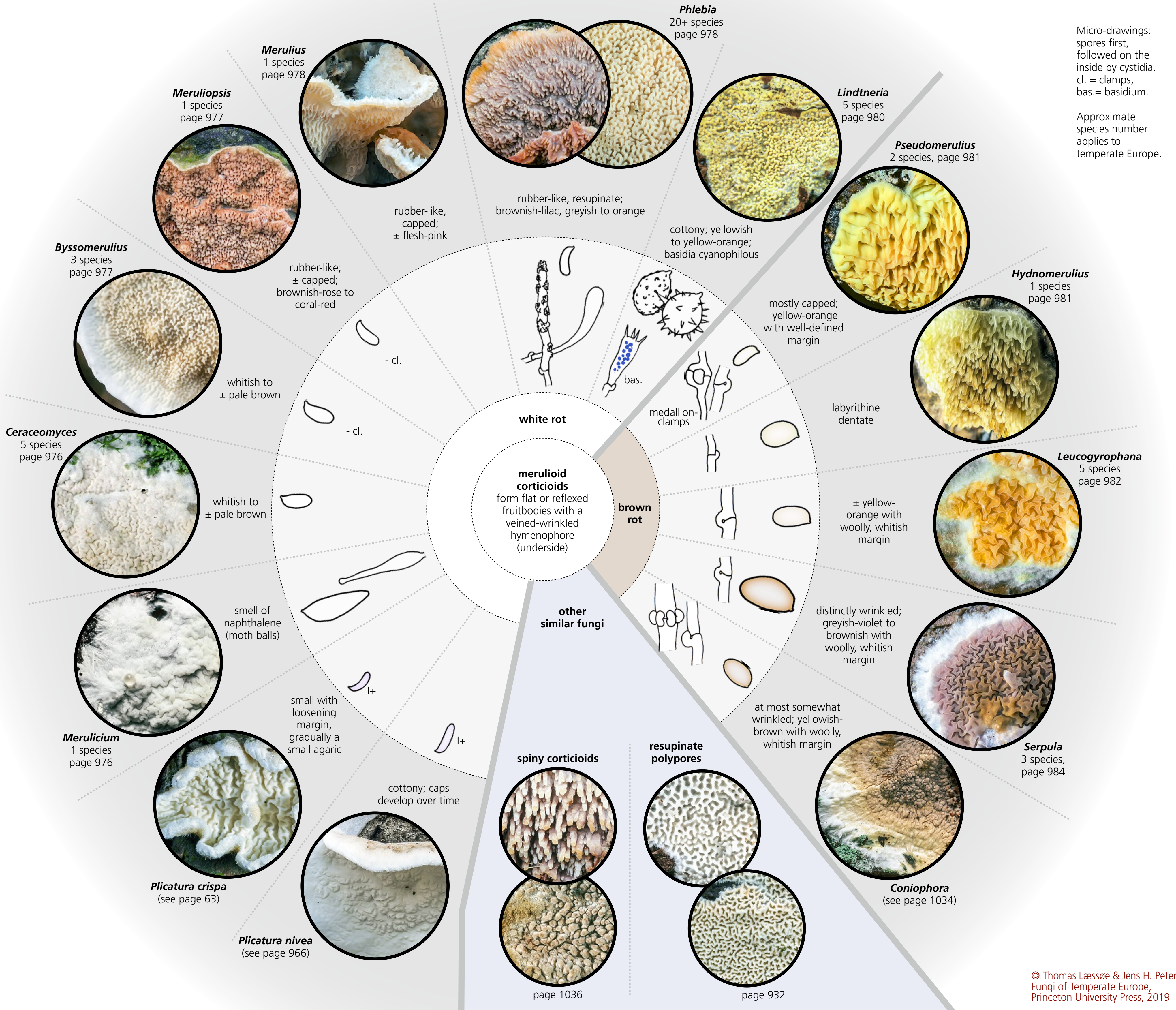
Other similar fungi:
– the wrinkled hymenophore grades into the spiny corticioids (page 1036).
– polypores with labyrinthine hymenophore (page 932) have sterile pore margins, whereas the species covered here have fertile margins.

See also the overview and the references to further reading on page 960.


wrinkled hymenophore


hymenophore with radiating wrinkles


veined hymenophore



Fragile corticioids

This rather poorly defined form group includes resupinate corticioids where the fruitbody is relatively loosely attached to the substrate. They may be either cobweb-like, cotton-like or flaky and fragile. Species with thin, waxy or gelatinous fruitbodies are not included here, but amongst the firm, white or coloured corticioids with a ± smooth hymenophore.

Species in this group are best identified by using a compound microscope but macro-morphology may provide useful clues. Since all the species included have a loose hyphal structure it is easy to prepare flat preparations for use under the microscope – and as the hyphal structure can be seen clearly, they are much easier to work with than the waxy or gelatinous species.

OTHER SIMILAR FUNGI:

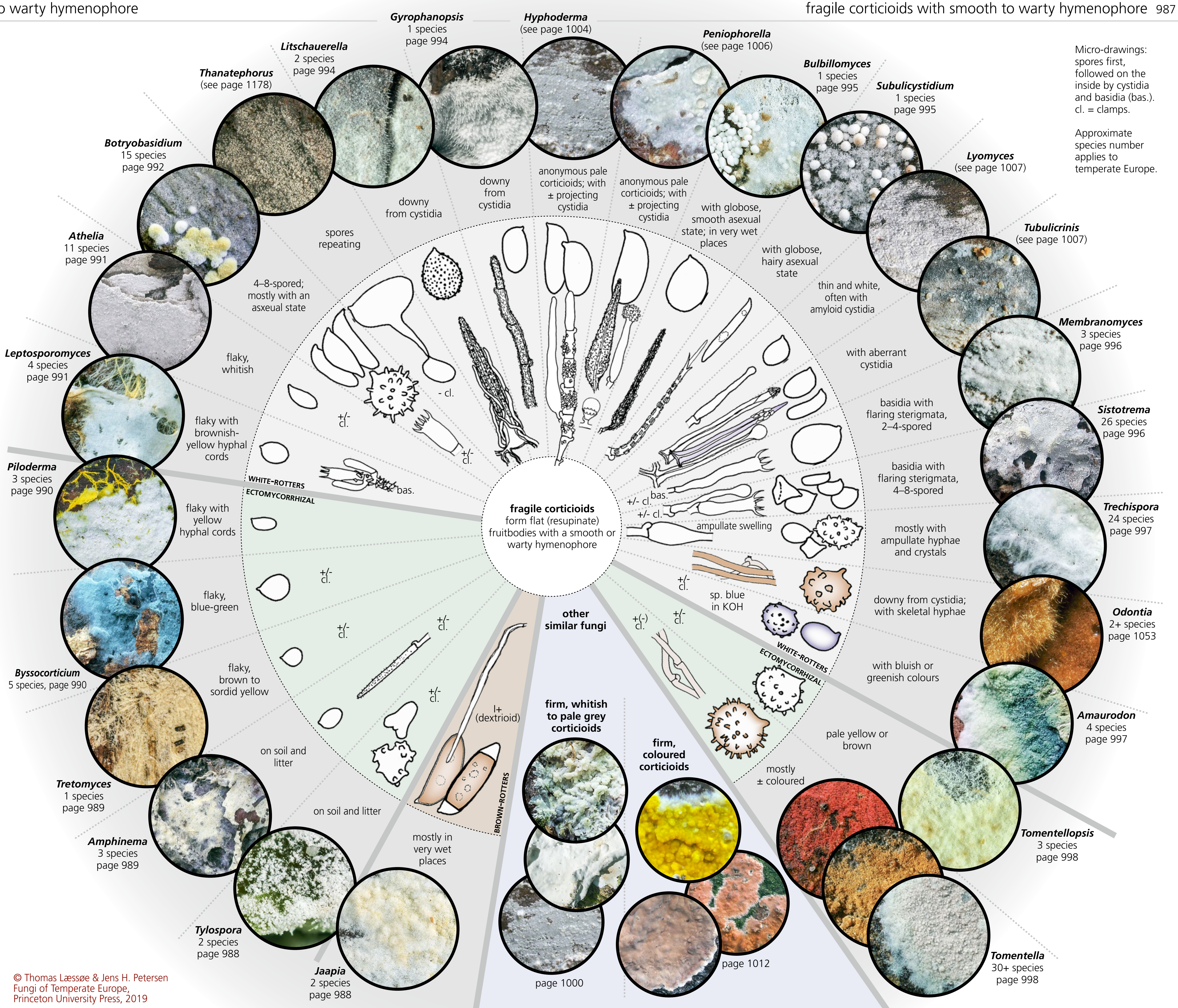
– whitish to pale grey corticioids with firm, tougher, waxy structures (page 1000).

– coloured corticioids with firm, tougher, waxy structures (page 1012).

See also the overview and the references to further reading on page 960.

Cobweb-like fruitbodies of *Botryobasidium* with 8-spored basidia in close up.

Loosely constructed fruitbodies of *Tomentella* with 4-spored basidia.



Micro-drawings: spores first, followed on the inside by cystidia and basidia (bas.). cl. = clamps.

Approximate species number applies to temperate Europe.

Smooth, firm, ± whitish corticioids

This form group includes smooth, firm, relatively well-attached, resupinate corticioids with whitish or pale greyish hymenophores. The texture of the fruitbodies may be cheesy, waxy or leathery.

Most species in this group, also colloquially called 'white paint', can only be recognized with the aid of a microscope and suitable reagents.

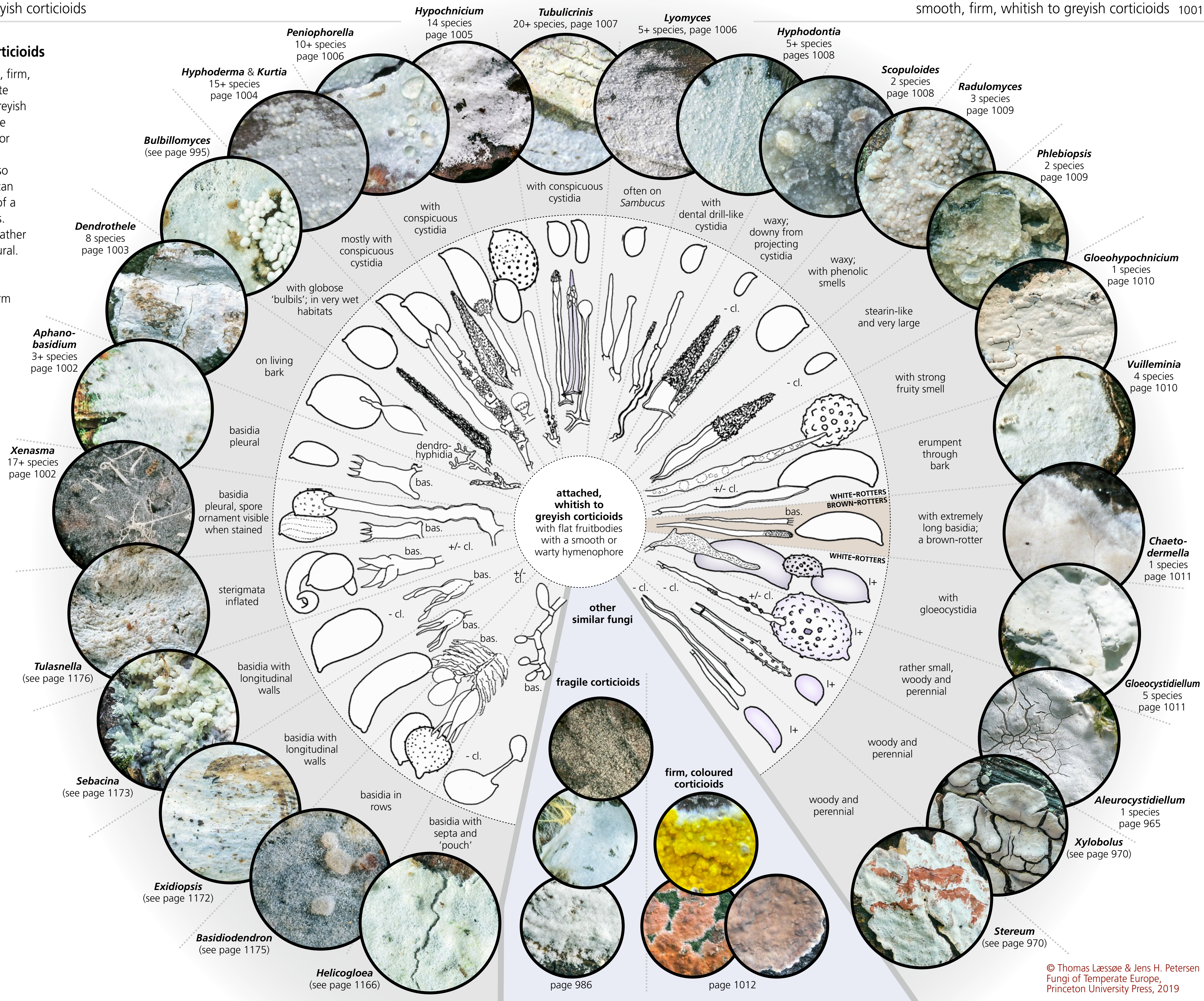
Basidia attached to the side, rather than at the base, are termed pleural.

OTHER SIMILAR FUNGI:

– the distinction between this form group and the fragile, white corticioids is not clear-cut (page 986).

– dark grey and pinkish-buff species are treated amongst the attached, coloured corticioids (page 1012).

See also the overview and the references to further reading on page 960.



Micro-drawings: spores first, followed on the inside by cystidia.
cl. = clamps.
bas. = basidia

Approximate species number applies to temperate Europe.

Smooth, firm, coloured corticioids

This form group includes resupinate corticioids with buff, brown, dark grey or vividly coloured, smooth to warty hymenophores. The texture of the fruitbodies varies from gelatinous, cheesy, waxy to leathery.

Some of the more brightly coloured species can be identified in the field, but the more anonymous require microscopic examination. It is difficult to make suitable preparations of the waxy species. The preparations are hard to make sufficiently thin and the tissues may be filled with lots of 'goo' that makes it difficult to make out the details.

Other similar fungi:

– species with completely white or pale grey fruitbodies (page 1000).

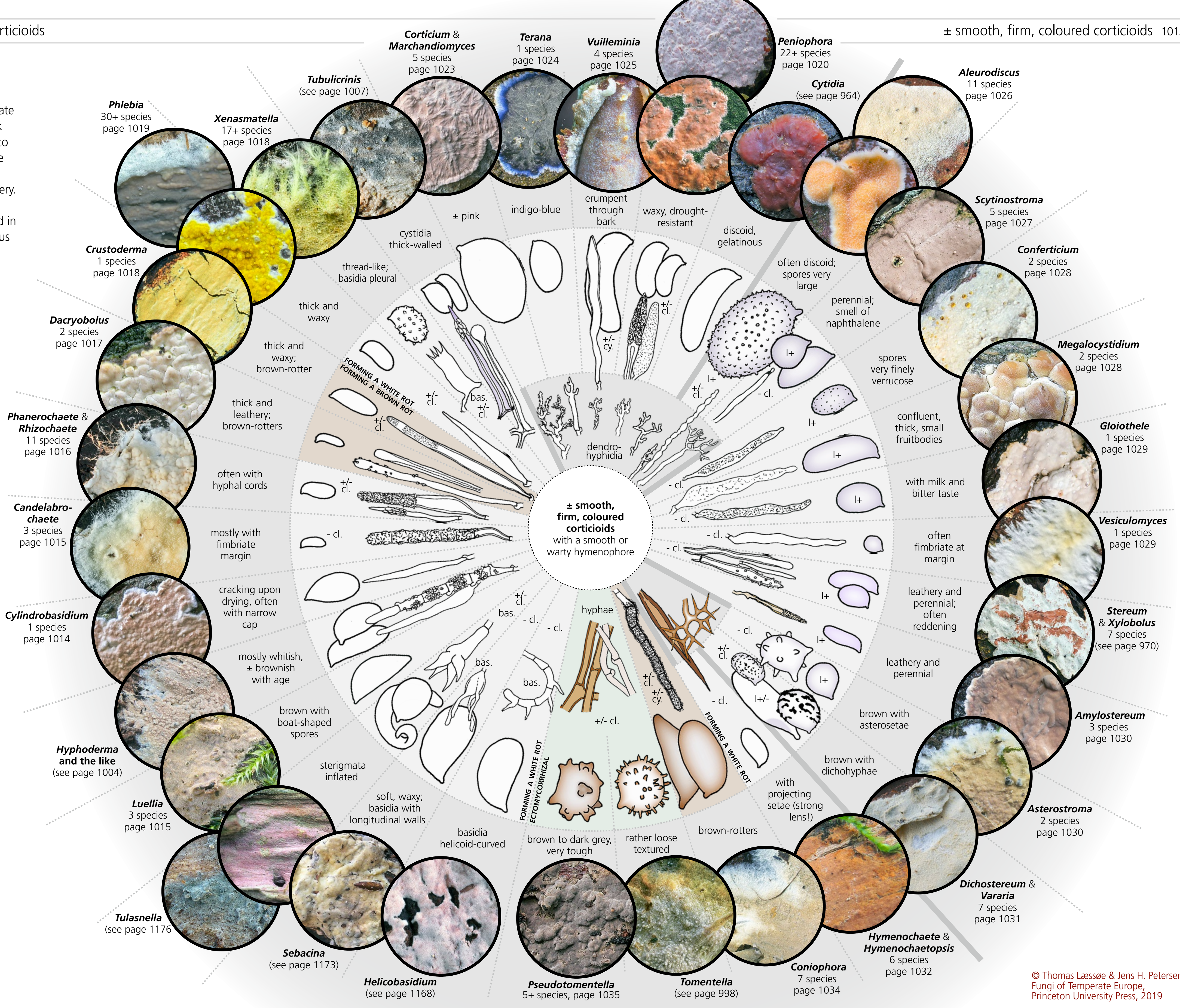
– species with fragile, cobweb-like or flaky fruitbodies (page 986).

– resupinate jelly fungi (with divided basidia) (page 1162).

See also the overview and the references to further reading on page 960.

Micro-drawings: spores first, followed on the inside by cystidia.
cy. = cystidia
cl. = clamps.
bas. = basidia
I+ = amyloid

Approximate species number applies to temperate Europe.



Spiny corticioids

This form group includes resupinate and reflexed, thin-fleshed corticioids with a dentate to spiny hymenophore. A few species can be identified in the field, but in general the most important characters are the appearance of the spores and basidia, and in some cases the types of cystidia and hyphal structures, all of which require microscopy.

OTHER SIMILAR FUNGI:

– the hydnoids are more thick-fleshed and often have a cap and stem (page 1054).

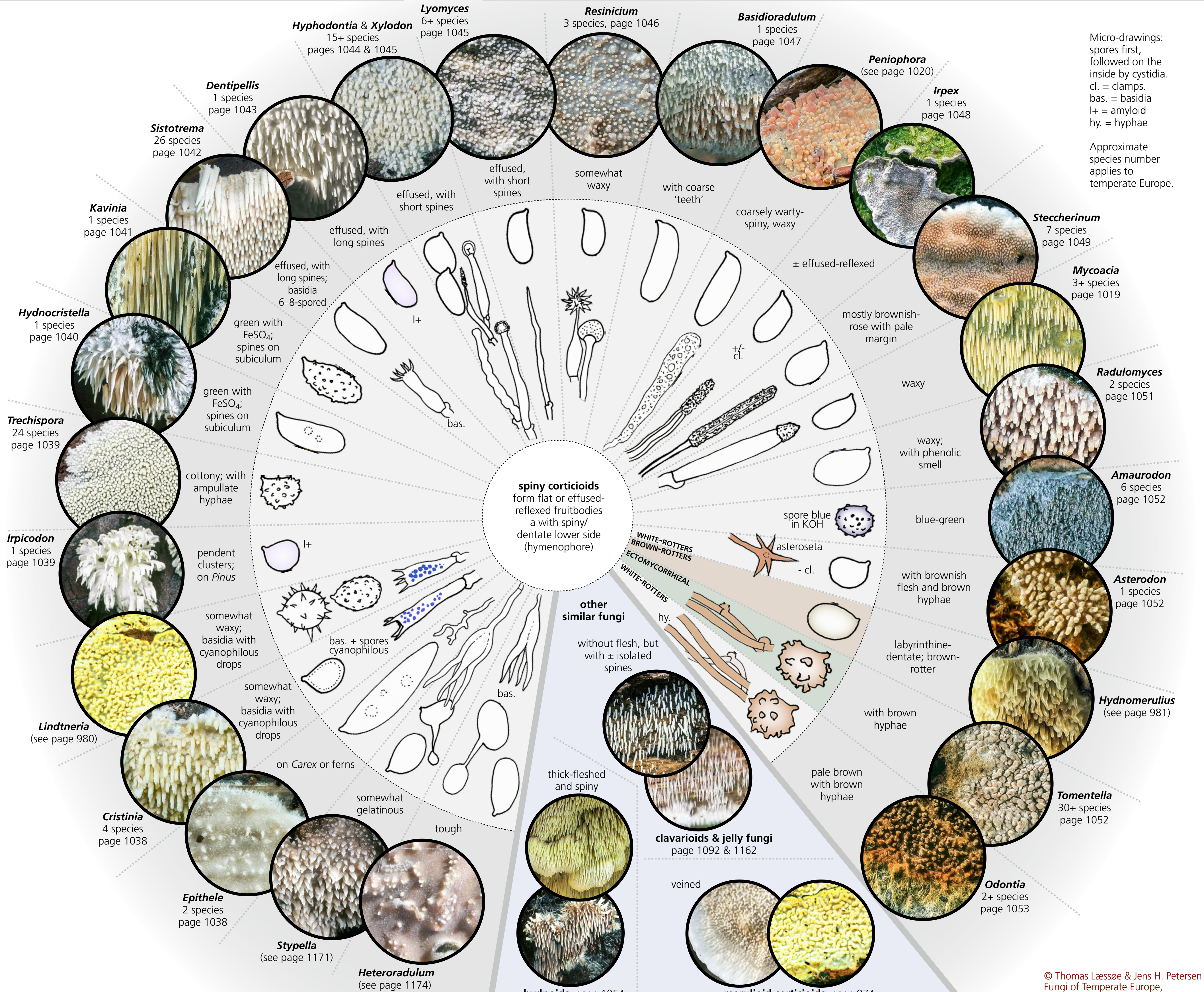
– pendent clavarioids form 'clubs' directly on the substrate, rather than in connection with a subiculum or the flesh (page 1092).

– the merulioid corticioids have a ± veined hymenophore, which may partially split into rounded 'teeth' (page 974).

– the pores of annual, resupinate polypores may, with age, split into 'teeth' (page 932).

See also the overview and the references to further reading on page 960.

spines (round in section) 'teeth' (flattened)



Micro-drawings: spores first, followed on the inside by cystidia.
cl. = clamps.
bas. = basidia
I+ = amyloid
hy. = hyphae

Approximate species number applies to temperate Europe.

Hydnoids

The hydnoids are defined here as either stemmed or thick-fleshed fungi with a spiny or dentate hymenophore. Fungi with thin, resupinate, spiny fruitbodies are treated under the form group corticioids (page 960).

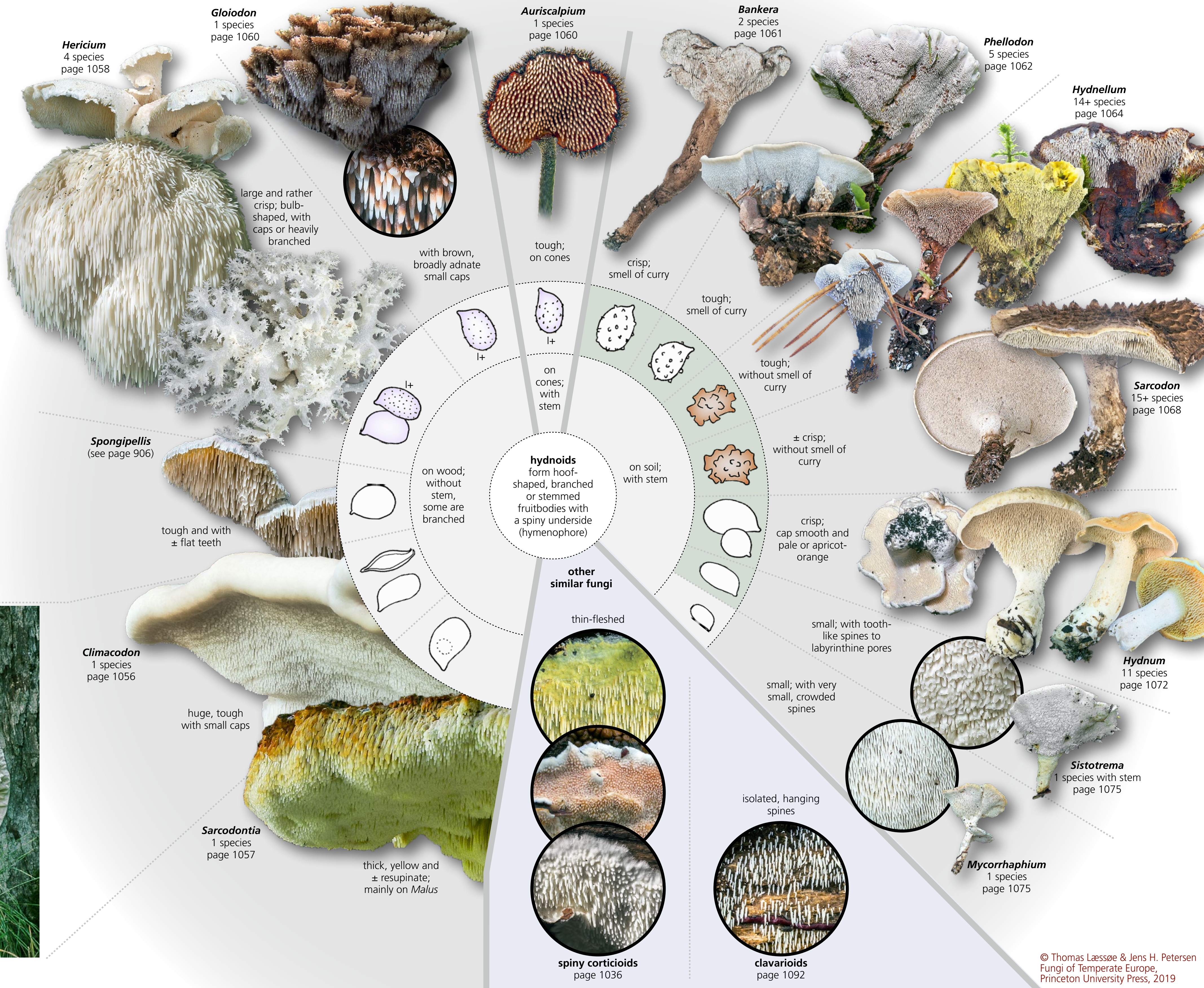
The hydnoids constitute a form group of species that, for example, belong to the orders *Thelephorales*, *Cantharellales* and *Russulales*.

Other similar fungi:
– spiny species with flat (resupinate) fruitbodies and thin flesh are included under the corticioid fungi (page 1036).
– species with isolated spines that lack a common flesh are treated under the clavarioids (page 1092).

Further reading: 50, 142, 163, 221, 229, 346.

Micro-drawings: spores and cystidia

Approximate species number applies to temperate Europe.



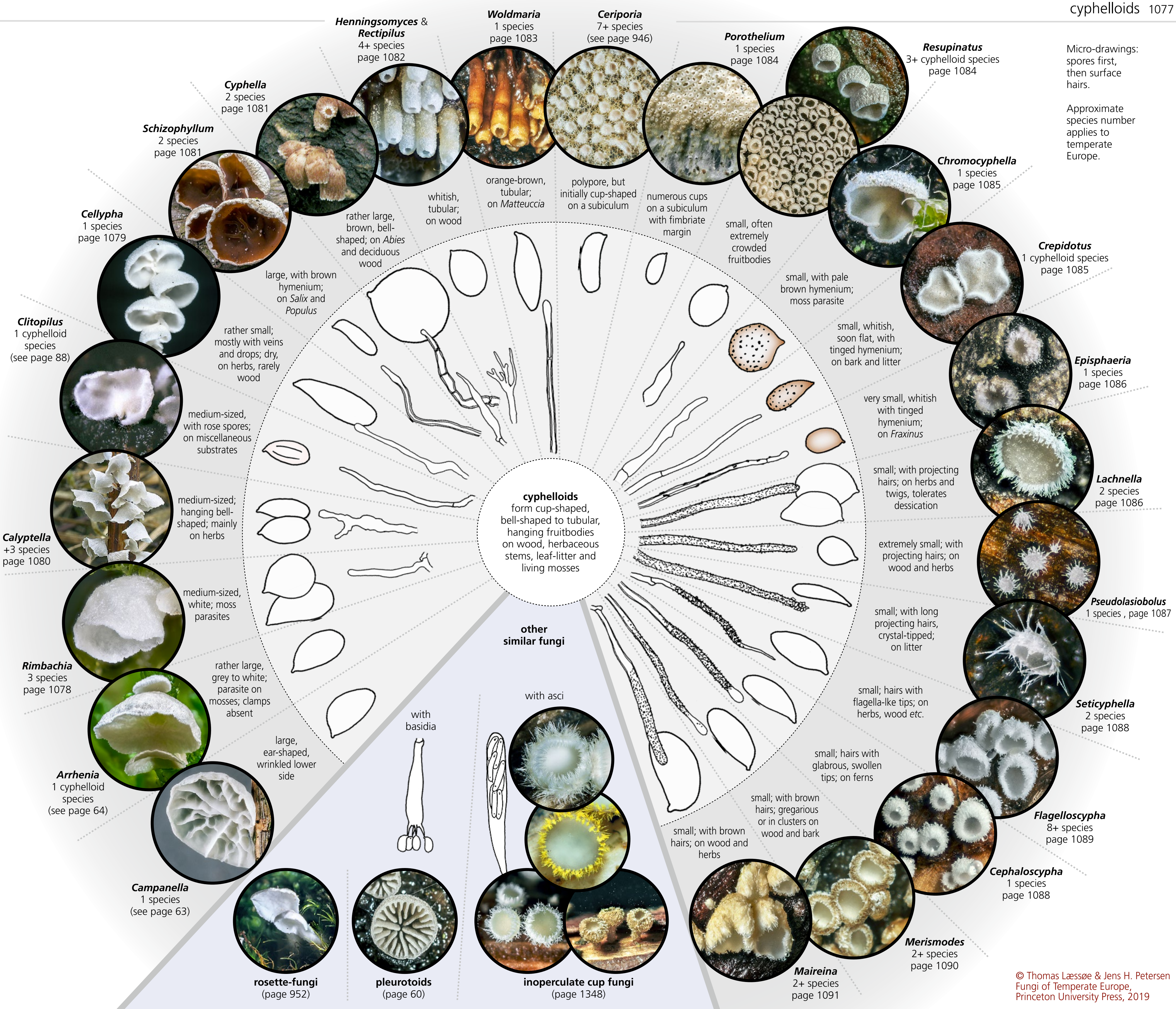
Cyphelloids

This form group includes basidiomycotes with small cup-shaped, bell-shaped or tubular fruitbodies on various substrates. The largest fruitbodies are up to 10 mm wide (*Schizophyllum amplum*), while the smallest are only around 0.2 mm wide (*Pseudolasiobolus minutissimus*). The fruitbodies are generally positioned with the hymenium pointing downwards, allowing the spores to fall freely when released.

Most cyphelloids are reduced agarics, *i.e.* members of *Agaricales* that have become gill-less during the process of evolution. Some polypores, *e.g.* species of *Ceriporia* (page 946), may initially recall cyphelloids but, with age, the cups join to form 'normal' polypore fruitbodies. The numerous separated tubes in *Fistulina hepatica* (page 845) and the unusual 'gills' of *Schizophyllum commune* (page 62) can be interpreted as many cyphelloid fruitbodies joined on a common fleshy meta-structure. These species are also nested within the *Agaricales*.

Other similar fungi:
– many species of *e.g. Hyaloscyphaceae* may look similar, but the apothecia can point in all directions and they tend to look neater and less irregularly hairy. They form spores in asci (page 1372).
– some rosette-fungi recall large cyphelloids, but cyphelloids are never long-stemmed (page 952).
– pleurotoids are typically larger, with more well-developed gills (page 60).

Further reading: 5, 6, 40, 156, 186.



Micro-drawings: spores first, then surface hairs.

Approximate species number applies to temperate Europe.

Clavarioids

Clavarioids includes *Basidiomycota* with normal, one-celled basidia and thread-like, awl-shaped, clavate or branched fruitbodies. Most clavate fruitbodies are negatively geotropic (they grow/point upwards), but some species with very small fruitbodies are ageotropic (the orientation is random) and species in the genus *Mucronella* ▷▷ are positively geotropic (they point downwards).

The clavate fruitbody is one of the simplest, most basic types of fungal fruitbody, and clavarioids have arisen numerous times through the evolution of the fungal kingdom. Clavate fruitbodies occur in *Ascomycota* (*e.g.* earthtongues), within the rust fungi, the jelly fungi and in numerous places amongst the remaining *Basidiomycota* with one-celled basidia, *e.g.* amongst the *Agaricales*.

The group of clavarioids with one-celled basidia includes about 20 genera, with around 200 species in temperate Europe.

Many small clavarioids live as decomposers of plant material, *e.g.* on stems of herbs or leaves. Some species of *Typhula* ▷▷ may parasitize plants. Amongst the larger clavarioids the genera *Ramaria* ▷▷, *Clavariadelphus* ▷▷ and *Thelephora* ▷▷ are ectomycorrhizals.

Like the hygrocyboid fungi (page 142), some or all species of *Clavaria*, *Clavulinopsis* and *Ramariopsis* ▷▷ may live in a not yet understood symbiosis with herbs (page 18). These species are mostly very demanding with regard to habitat, and, among other things, are sensitive to fertilizers, preferring habitats with a long continuity. They often share habitat with a number of rare hygrocyboids, entolomatoids, earthtongues – *e.g.* in unimproved grasslands or in damp forests on mull soils – and they are particularly good indicator species of especially biodiverse fungus habitats.

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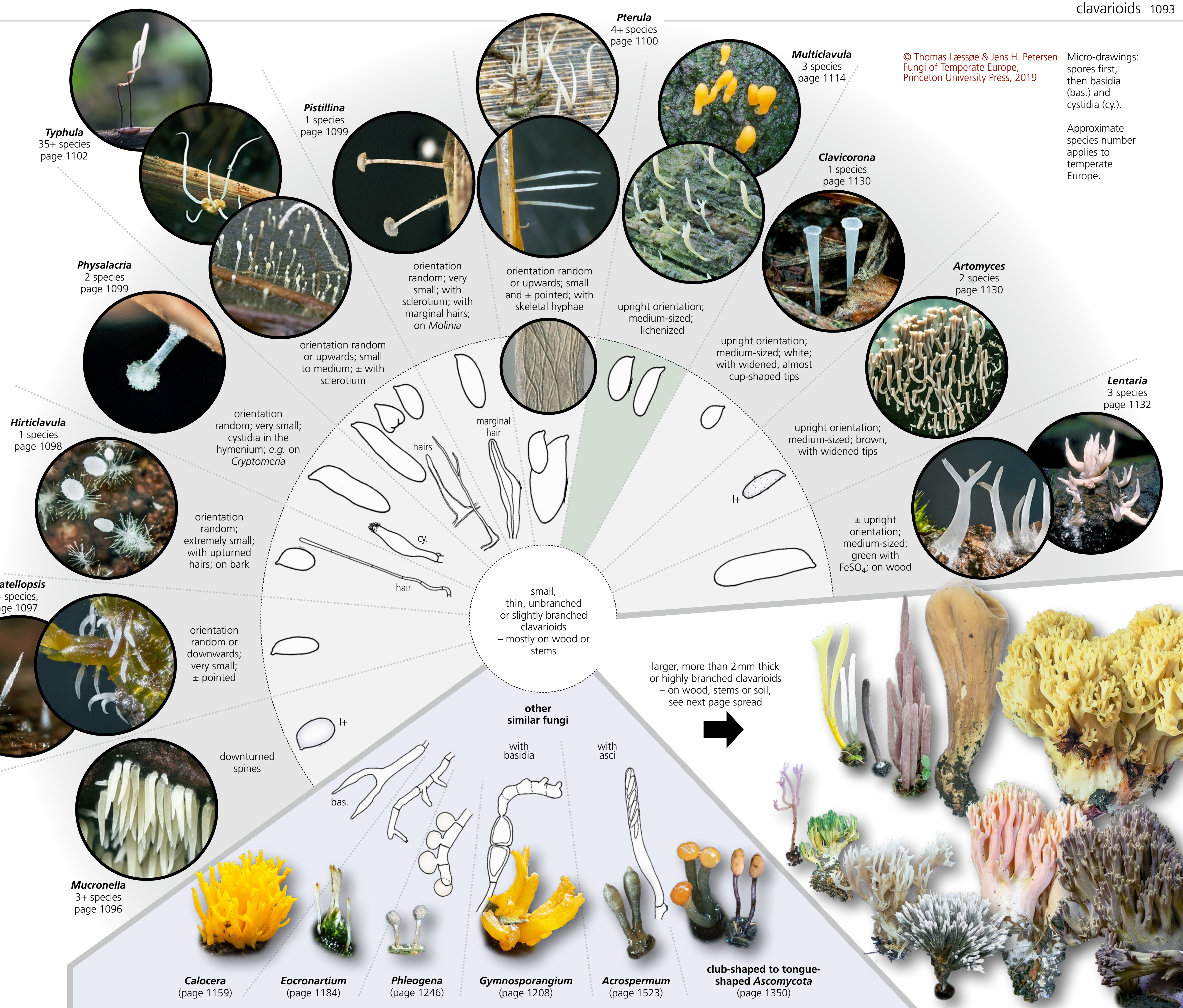


Micro-drawings: spores first, then basidia (bas.) and cystidia (cy.).

Approximate species number applies to temperate Europe.

Clavarioids

continued from previous page spread . . .

Other similar fungi:

– species of *Calocera* look similar but have rubbery textures and tuning fork-shaped basidia (page 1159).

– greyish-white species of clavarioids with septate basidia are treated with the jelly fungi (page 1164).

– orange-yellow, gelatinous clavarioids with teliospores that germinate with septate basidia belong to the rust fungi (page 1208).

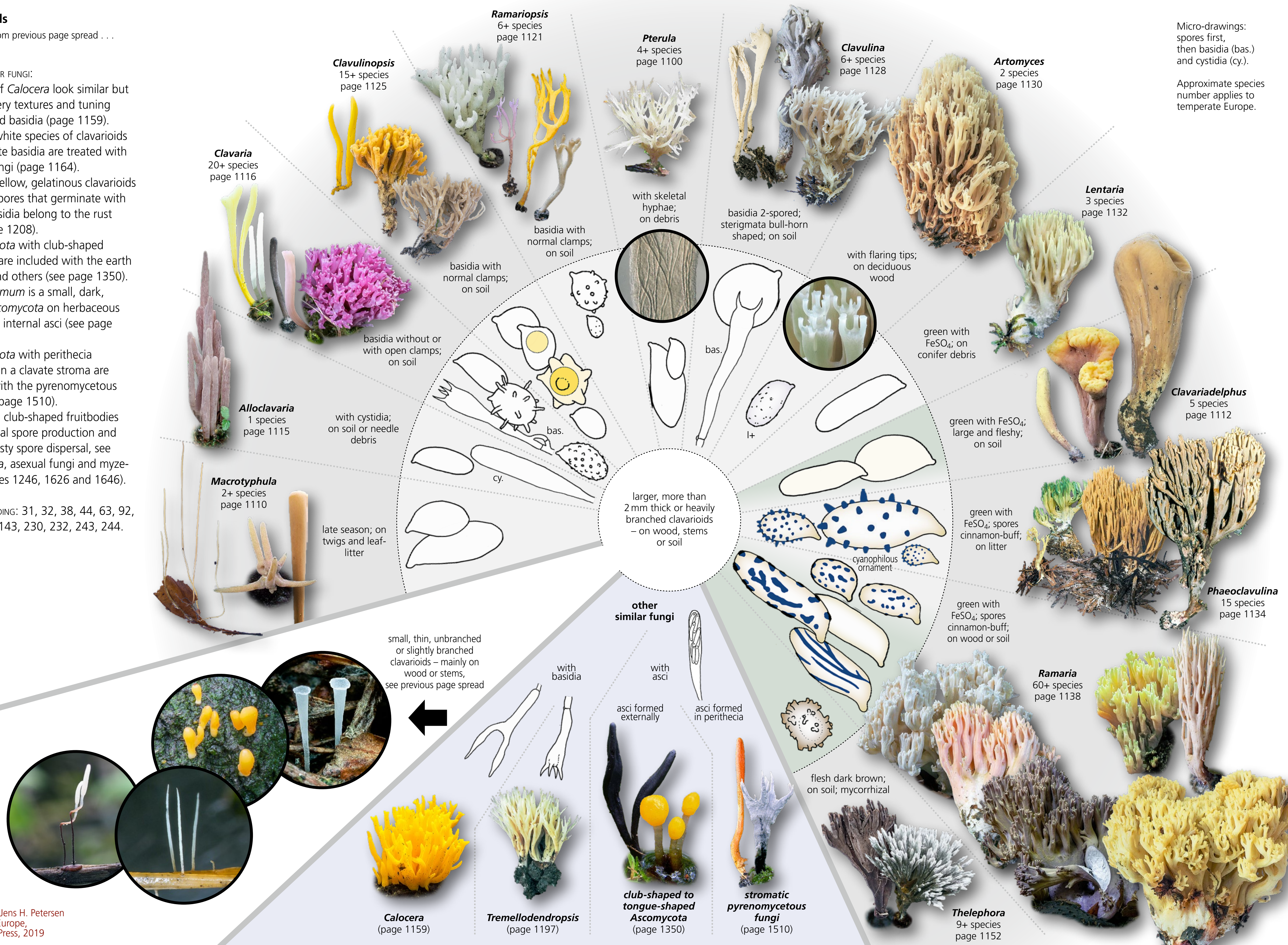
– *Ascomycota* with club-shaped apothecia are included with the earth tongues and others (see page 1350).

– *Acrospermum* is a small, dark, clavate *Ascomycota* on herbaceous stems with internal asci (see page 1523).

– *Ascomycota* with perithecia immersed in a clavate stroma are included with the pyrenomycetous fungi (see page 1510).

– for small, club-shaped fruitbodies with internal spore production and passive, dusty spore dispersal, see *Phloeogena*, asexual fungi and myzetozoa (pages 1246, 1626 and 1646).

Further reading: 31, 32, 38, 44, 63, 92, 100, 142, 143, 230, 232, 243, 244.



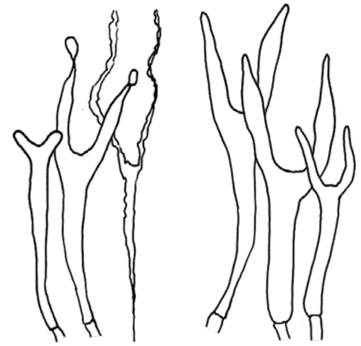
Dacrymycetales

The *Dacrymycetales* is a natural group characterized by tuning fork-shaped basidia, mostly septate spores that bud off microconidia, and by the predominantly orange-yellow, gelatinous to rubbery fruitbodies. Mature spores are best studied from deposits on slides. Some species form simple asexual spores (arthrospores) from structures that are similar to the fruitbodies, but softer.

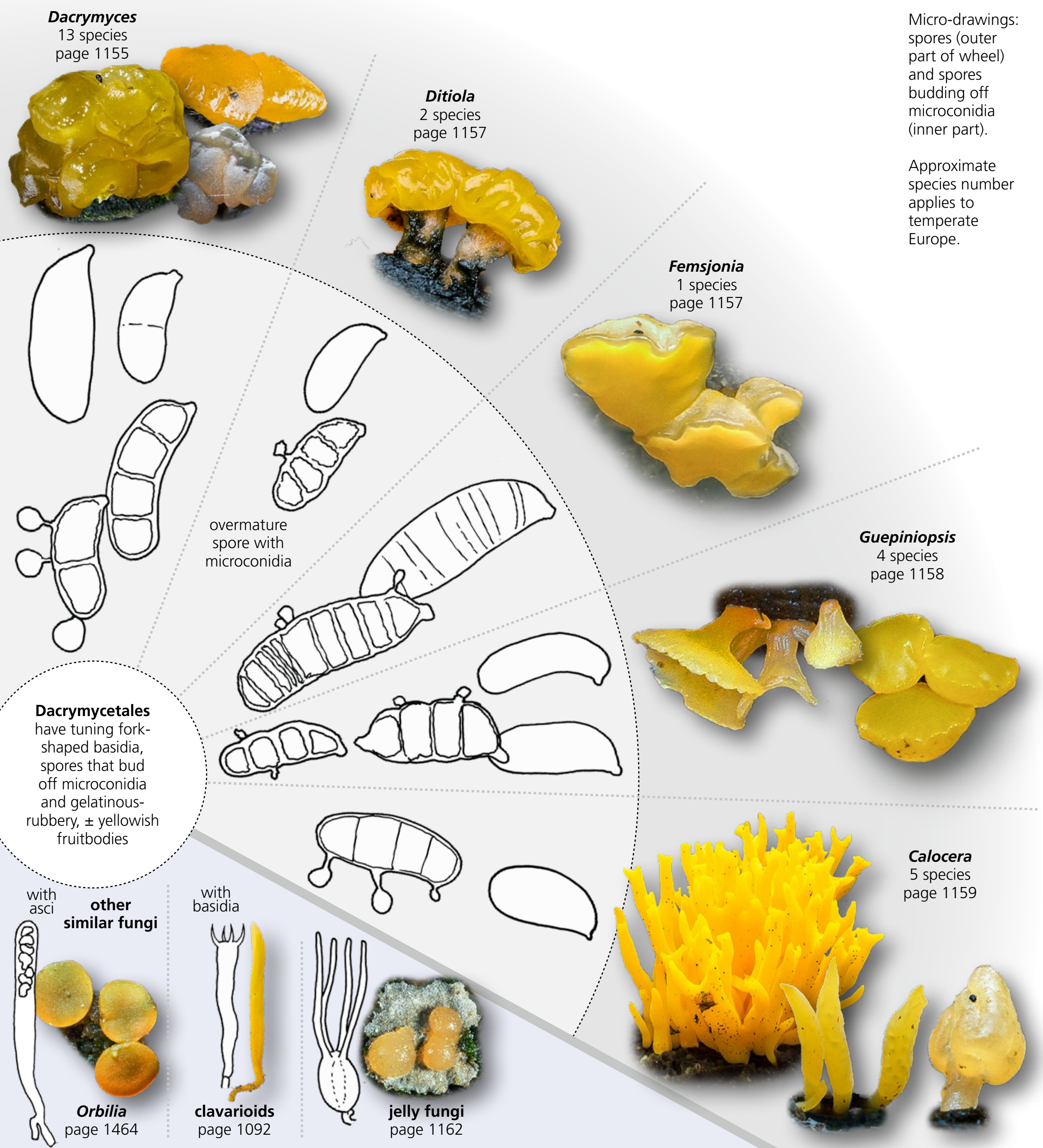
The individual genera are poorly delimited in relation to each other, and the largest genus, *Dacrymyces,* is not monophyletic.

All species are wood-decayers and form a brown rot. Some species, *e.g. Dacrymyces stillatus,* can cause serious damage to timber, including wooden window frames.

FURTHER READING: 50, 142, 163, 265.



Development of basidia (left); types of basidia (right).



Micro-drawings: spores (outer part of wheel) and spores budding off microconidia (inner part).

Approximate species number applies to temperate Europe.

Dacrymyces form small, cushion-shaped to turbinate fruitbodies that may aggregate in resupinate structures. The spores have up to nine septa. All are wood-degraders and brown-rotters.

Dacrymyces stillatus often occurs in both a sexual and an asexual state on the substrate. The asexual state is reddish-orange and soft, and can easily be squashed (lower image), while the sexual state is adnexed, translucently yellow and firmer, more rubbery-gelatinous. The hyphae lack clamps. The basidia are tuning fork-shaped. The thick-walled spores are flattened on one side, at maturity have three thick septa and measure 12–14 × 3.5–4 µm; they bud off small, globose conidia from each cell. Occurs on moist, rotten wood of coniferous and deciduous trees.

May be difficult to separate from *D. lacrymalis* ▽ but that species lacks the prominent asexual state and has somewhat thinner-walled spores.

Widespread and very common; all year.

Dacrymyces lacrymalis is bright yellow, translucent, wrinkled, narrowly attached, medium-sized, *Dacrymyces* that does not have a proper stem. The spores have three somewhat thickened septa and measure 12–14 × 3.5–4 µm. Occurs mostly on decomposed wood from deciduous trees, more rarely on conifer wood.

The similar *Dacrymcyes stillatus* △ is usually accompanied by a reddish asexual state.

Widespread and common; all year.

Jelly fungi

This form group includes species that mostly have septate, long, sterigmate basidia and spores that can usually produce a copy of themselves (repeating to form secondary spores). Many species are gelatinous and have basidia imbedded in a protective gel. The sterigmata find their way from within the fruitbody to the surface, where the spores are formed.

The fruitbodies are highly variable in shape and colour, from flat (resupinate), verrucose or spiny, to large, folded, brain-like, clavate, branched or cap-like. One group of jelly fungi does not even produce obvious fruitbodies, but occurs either as parasites inside other fungal fruitbodies or forms almost invisible films on, for example, wood.

As defined above (aberrant basidia and repeating spores), the jelly fungi is a form group that also includes fruitbodies that are not jelly-like, and phylogenetically they usually belong to the subphylum *Pucciniomycotina* and the orders *Auriculariales*, *Cantharellales*, *Sebasinales* and *Tremellales*, all of which are within the subphylum *Agaricomycotina* (page 13).

Jelly fungi are decomposers or parasites on plants or other fungi. A group of species are part of the so-called 'orchid mycorrhiza', where orchids parasitize the fungi involved.

Jelly fungi includes more than 50 genera, with more than 200 species in temperate Europe. In this section, 30 genera are covered by the two wheels, including the most showy species. The majority of the genera not treated in this publication form resupinate, mostly invisible fruitbodies

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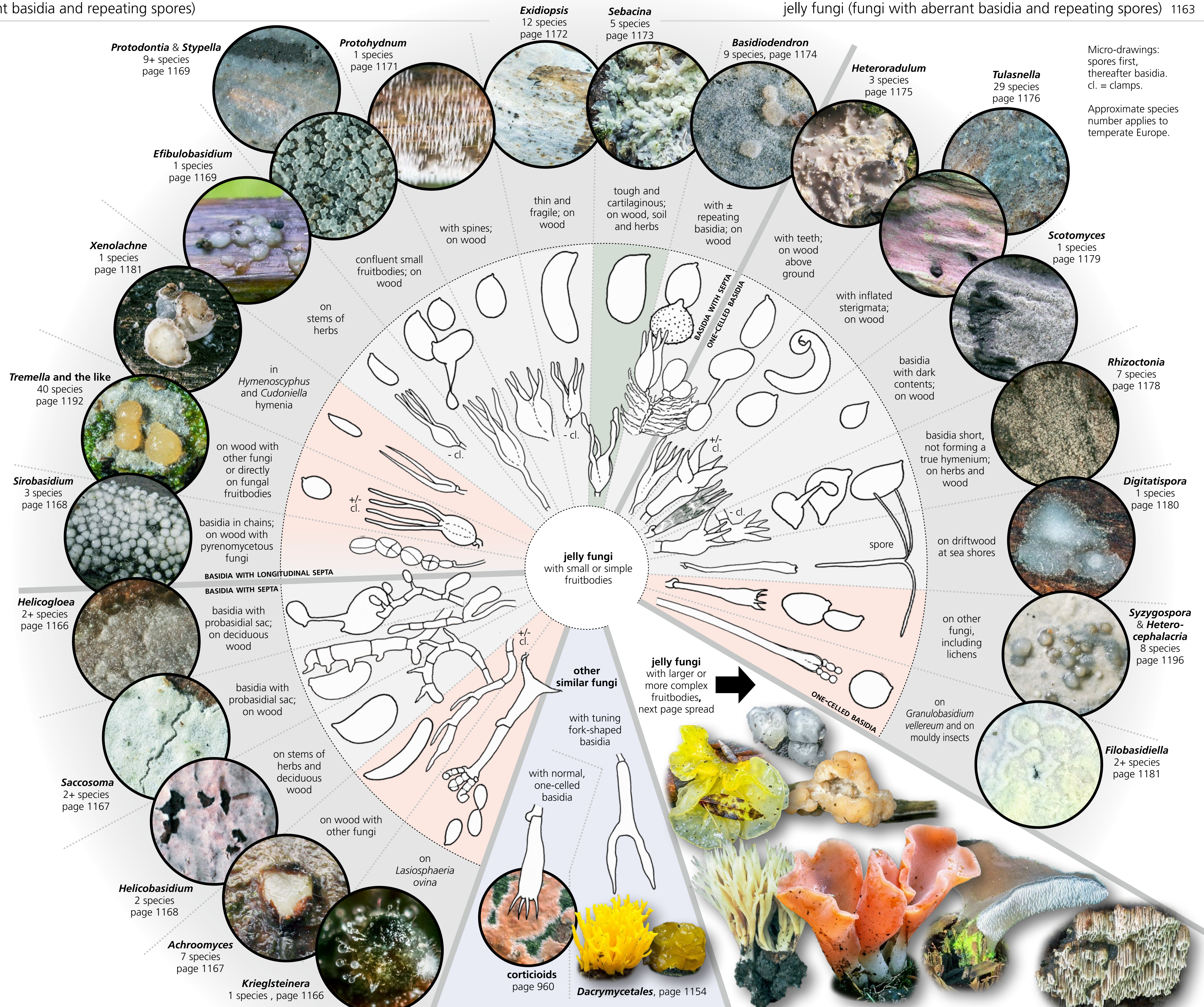

Jelly fungi

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or are parasites within other fungi or plants, *e.g.* the genera *Bourdotigloea*, *Endoperplexa*, *Hauerslevia*, *Herpobasidium*, *Heteroacanthella*, *Insolibasidium*, *Kriegeria*, *Naohidea*, *Occultifur*, *Oliveonia*, *Phragmoxenidium*, *Pseudostypella*, *Renatobasidium*, *Serendipita*, *Spiculogloea* and *Trimorphomyces*.

Other similar fungi:

– species of *Dacrymycetales* are also gelatinous but are mostly yellow and have characteristic, tuning fork-shaped basidia. The spores are mostly septate and do not repeat. However, conidia are often produced directly from the spores (page 1154).

– resupinate jelly fungi can be very difficult to tell apart from corticioid fungi; those, however, have one-celled basidia and spores that do not repeat (page 960).

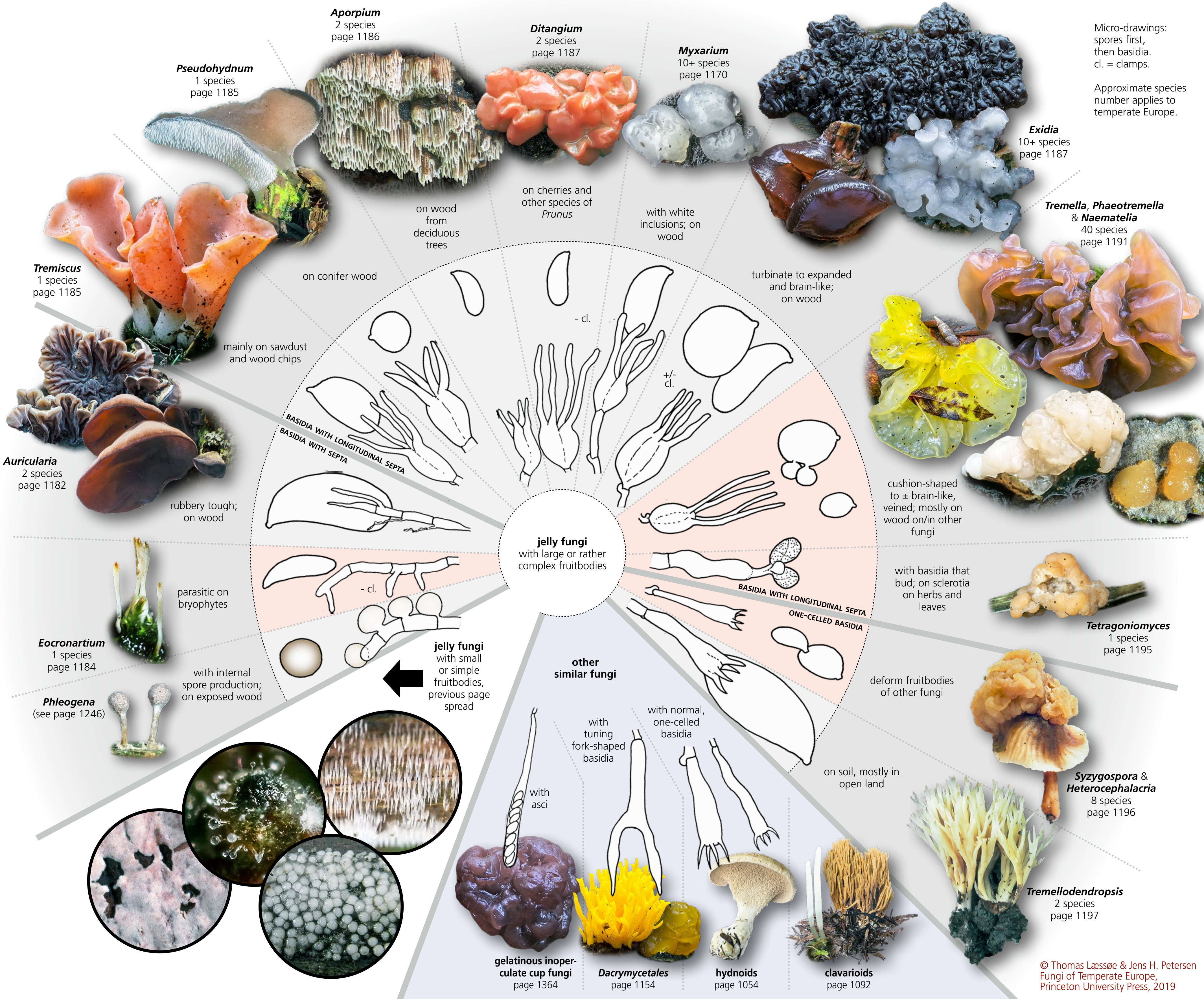
– *Aporpium* may be confused with resupinate polypores (page 932).

– *Pseudohydnum* may be confused with hydnoids, but hydnoids are not gelatinous (page 1054).

– *Tremellodendropsis* and *Eocronartium* may be confused with clavarioids (page 1092).

– some *Ascomycota*, *e.g.* *Ascotremella*, *Ombrophila* and *Bulgaria*, superficially recall jelly fungi, but they form spores in asci (page 1364).

Further reading: 50, 70, 100, 142, 163, 176, 189, 190, 192, 222, 268, 269, 270, 271, 306, 307.



Rusts and smuts

This group includes a number of biotrophic plant parasites that do not form proper fruitbodies; all belong to the *Basidiomycota*. There are about 30 genera of rusts and 20 of smuts in temperate Europe; the aim here is only to provide an overview of this group.

Rusts have a particularly complicated life-cycle that may involve up to five types of spore, and in many cases a change (shift) in host. The spore types can be summarized as follows. **Type 0** (spermogonia with spermatia): a basidiospore (Type IV) germinates on a suitable host and an internal mycelium develops from which tiny, flask-shaped spermogonia (n) are formed in spots on the host's surface. The spermatia may then transfer nuclei to suitable compatible hyphae on other spermogonia. **Type I** (aecidia with aecidiospores): the dikaryotic hyphae that result from fertilization with spermatia may then produce ± discoid aecidia in which dikaryotic (n+n) aecidiospores are formed. **Type II** (uredia with uredospores): in host-shifting species the aecidiospores infect a second host and a new dikaryotic mycelium develops from which uredia and uredospores are formed (n+n). **Type III** (telia with teliospores): a Type II mycelium finally forms telia with thick-walled teliospores (n+n) that typically overwinter. The following spring the teliospores germinate with 4-celled basidia after fusion of the two nuclei and a subsequent meiosis. **Type IV**: basidiospores (n) are then produced and can reinfect the first host.

Smuts and *Microbotryales* have much simpler life-cycles, infecting just one host and finally producing spores externally or internally. They can, for example, transform the inner parts of a flower to spores or may break out through stems, roots, seeds or leaves.

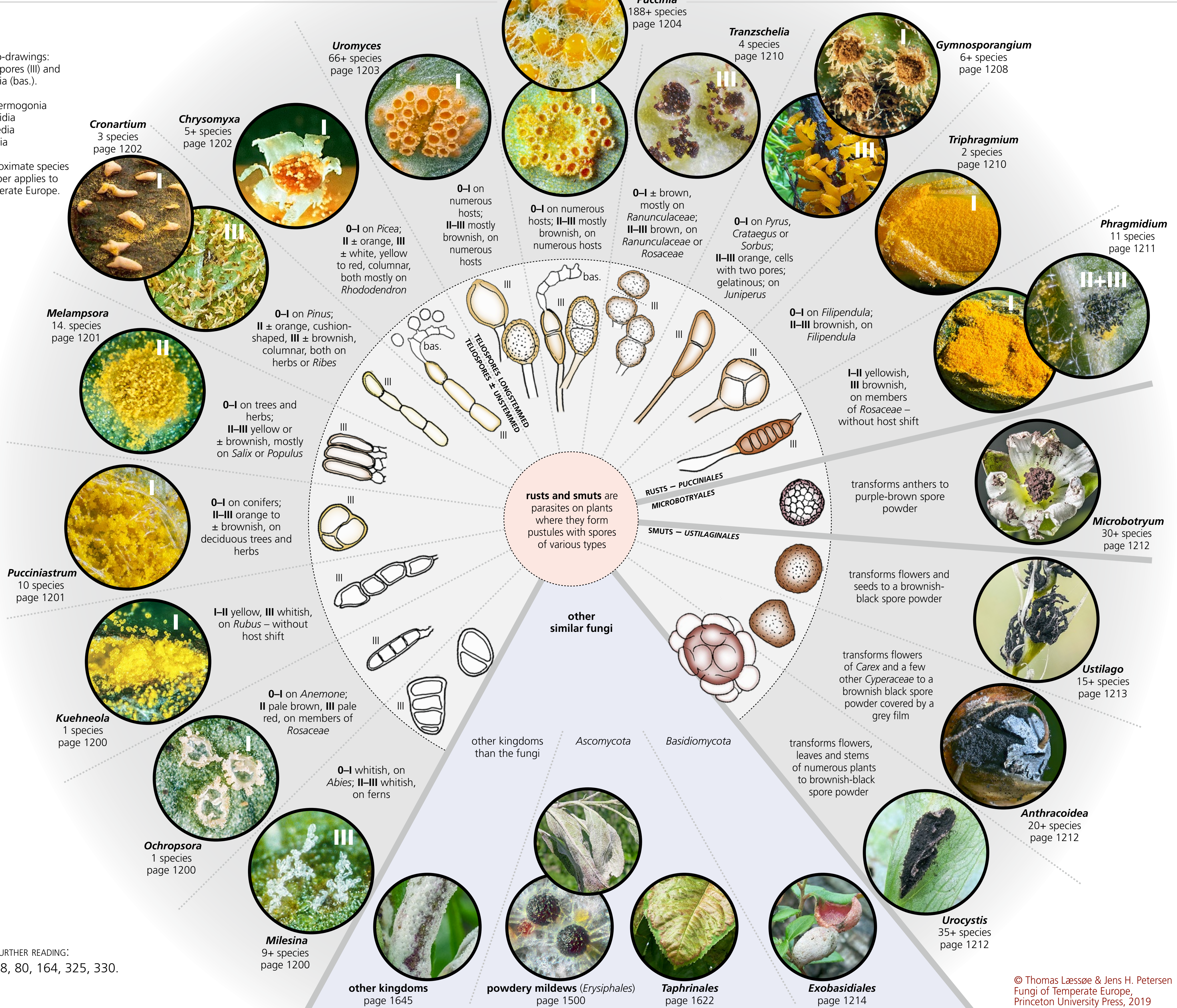
Both rusts and smuts are serious pathogens on crop plants.

Other similar fungi:
– numerous fungi and fungoid organisms live as parasites on plants, some of which may form structures that resemble those from rusts and smuts, see images in the blue section.

Micro-drawings: teliospores (III) and basidia (bas.).

0: spermogonia
I: aecidia
II: uredia
III: telia

Approximate species number applies to temperate Europe.



Further reading:
78, 80, 164, 325, 330.

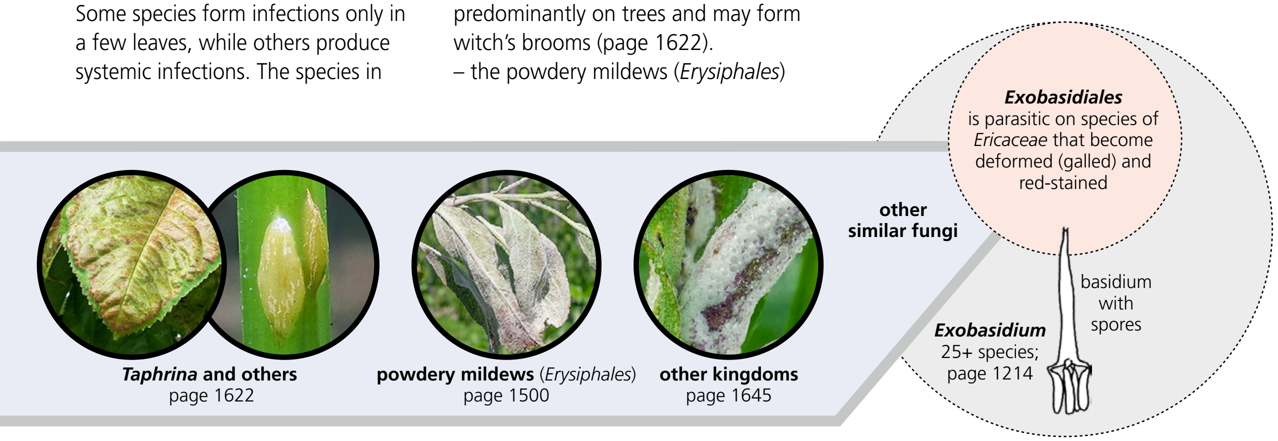
Exobasidiales

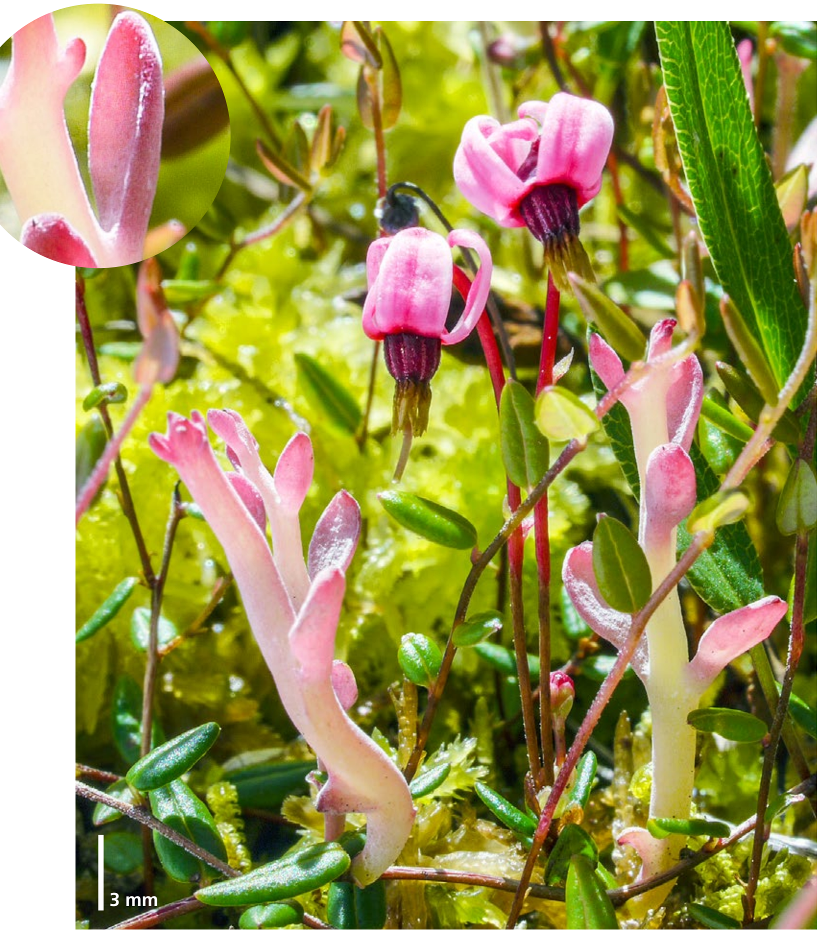
The order *Exobasidiales* has just one genus of biotrophic parasites in temperate Europe. It partly deforms shoots and leaves of the host, which is also stained red, and forms a whitish covering of hymenia that have long, one-celled basidia on some surfaces. Some species form infections only in a few leaves, while others produce systemic infections. The species in temperate Europe occur on shrubs and dwarf shrubs of the *Ericaceae*.

Farther south the related parasite *Laurobasidium lauri* ⋉ produces horn-like protuberances on *Laurus* trunks.

OTHER SIMILAR FUNGI:
– the ascomycote *Taphrina* occurs predominantly on trees and may form witch's brooms (page 1622).
– the powdery mildews (*Erysiphales*) are more mealy and, with age, form small, spherical fruitbodies with asci (page 1500).
– some organisms that resemble fungi, *e.g. Albugo*, have neither basidia nor asci (page 1645).

FURTHER READING: 80, 100, 164, 209.





Exobasidium oxycocci occurs within *Vaccinium oxycoccos* and *V. microcarpum*. The annual shoot of the host stretches and becomes pale, and finally is completely covered by erumpent basidia. The curved, 1–3-septate spores measure 12–15 × 3–3.5 µm.

Exobasidium rostrupii ⋉ occurs on the same host but only causes symptoms on the leaves, which acquire bright red spots on the upper side and have spore production underneath.

Widespread and probably rather common; summer–autumn.

Exobasidium vaccinii occurs on leaves of *Vaccinium vitis-idaea*. The leaves discolour red and become thick, and spores are formed on basidia on the mealy white lower sides. May also attack flower buds and young shoots, which become misshapen. The curved, 1–3(–7)-septate spores measure 11–19 × 2–4 µm; germinates with microconidia.

Exobasidium splendidum ⋉ and *E. juelianum* ▽ occur on the same host but form larger, systemic infections that include both leaves and stems.

Widespread and very common where the host occurs; summer–autumn.

Thomas Læssøe

Exobasidium juelianum is systemic and discolours the shoots of *Vaccinium vitis-idaea* bright red; it also causes dwarf growth. The spore-producing pale tissue is seen mostly under the leaves. The spores are either one-celled, or have one septum, and measure 9–14 × 2–4 µm.

Exobasidium splendidum ⋉, on the same host, is an even redder, more northern, 2-spored species with curved, 0–1-septate spores that measure 20–27 × 6–11.5 µm; *E. vaccinii* △ causes localized infections of single leaves, but not of whole shoots.

Widespread, common in the hemiboreal–boreal zones, rarer farther south; summer–autumn.

Exobasidium uvae-ursi infects plants of *Arctostaphylos uva-ursi*. The parasitized plants typically produce dense, annual shoots with numerous dark red leaves and stems. The hymenium is formed on the underside of the leaves. The curved, 1–3-septate spores measure 15–22 × 5–6 µm; germinates with microconidia.

Exobasidium sydowianum ⋉ occurs on the same host but the infection is limited to just tiny areas on the leaves.

Widespread in the hemiboreal–boreal zones, occasional, rare in the nemoral zones; summer–autumn.

Julia Kruse

Bird's nest fungi

Bird's nest fungi belong to the *Basidiomycota*, and produce basidia and spores within special egg-like structures called peridioles. In *Sphaerobolus* the single peridiole is shot actively away from the fruitbody. In other genera the small peridioles are held within cup-shaped structures, and are 'splashed out' by heavy raindrops. Traditionally, bird's nest fungi are included in the gasteroid form group.

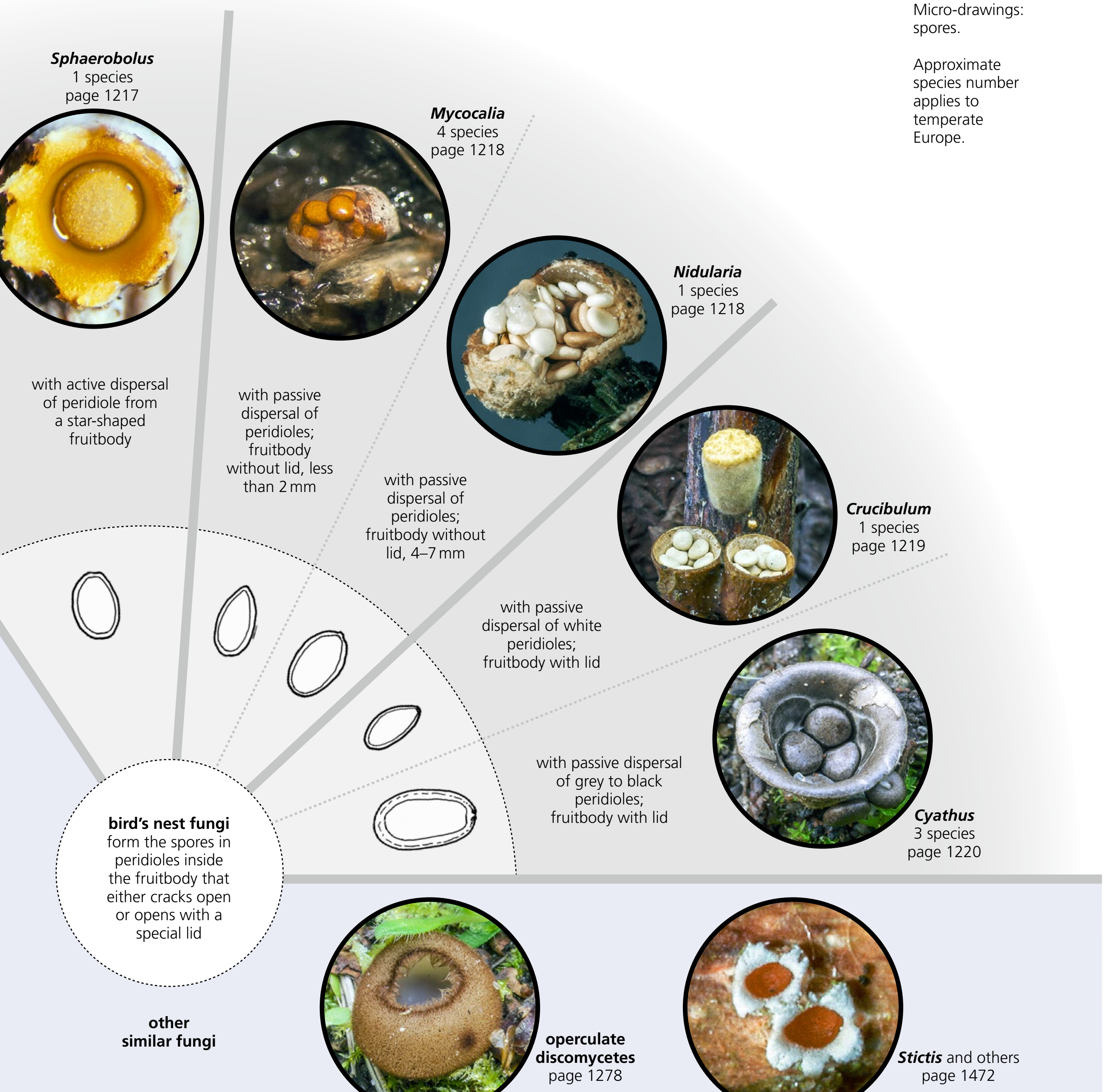
All species in the group are decomposers and occur typically on large herbaceous stems, wood or dung.

Other similar fungi:
– some operculate discomycetes may superficially resemble bird's nest fungi, but they do not have peridioles and the spores are borne in asci in a hymenium inside the cup (page 1278).
– *Stictis* may superficially recall *Sphaerobolus* but lacks peridioles and forms the spores in asci in a gelatinous hymenium (page 1472).

Further reading: 50, 92, 156, 241.

Micro-drawings: spores.

Approximate species number applies to temperate Europe.



Sphaerobolus stellatus is a unique, approximately 2 mm wide gasteroid fungus that opens in a star-like fashion, after which a ± orange-brown ball (a peridiole) is shot several metres away. During the opening an orange colour is seen (upper image), and after shooting a pale projecting 'balloon' is seen (middle image). Spores and basidia are held within the peridiole. The hyaline, thick-walled spores measure 6–10 × 5.5–6.5 µm. Occurs on litter, very decomposed wood, and old dung, mainly in open habitats.

Distinctive and unlikely to be misidentified. Only one other European genus, *Pilobolus* (page 1642), has the ability to propel a spore ball several metres, but the mechanism used by the two genera is quite different. In *Sphaerobolus* the propelling force is created by tensions between six different wall layers. At maturity, one of the layers under the peridiole swells, and the resulting tension results in an inversion of the upper layer and the peridiole is shot away. The inverted layer is the pale 'balloon'. *Pilobolus* propel the spore ball by creating an internal pressure within the head that eventually 'explodes' and delivers the necessary force.

Widespread and common; mainly June–December.

Jan Vesterholt

Jan Vesterholt

Stinkhorns

The stinkhorns and their allies (*Phallales*) is a monophyletic group of fungi that form spores internally in a bulb-shaped 'witch's egg'. At maturity, the egg opens to reveal a slimy, dark spore mass. At the same time the fruitbodies emit a nauseating smell of carrion or faeces that attracts flies and other insects, which then disperse the spores. The spore mass also contains sugars as a reward for the insects. All species live as decomposers and are traditionally included in the gasteroid form group.

The insect-aided dispersal limits the potential distance that spores can travel compared to normal wind-disseminated spores. A consequence, it has been possible to follow the relatively slow spread of some of the introduced species in this order, *e.g.* *Clathrus archeri*.

Other similar fungi:
– some basidiomycote truffles form structures similar to witch's eggs, but these stay underground (page 1256).

Further reading: 50, 92, 156, 241.

Micro-drawings: spores.

Approximate species number applies to temperate Europe.

Species of ***Mutinus*** are small stinkhorns with a not very clearly delimited fertile area on top of the stem. Has red and orange colours.

Mutinus caninus is a very slender stinkhorn with orange colours under an olive-black spore mass, as well as part way down the stem. The white witch's egg is elongated and has orange colours when sectioned. It is not as foul-smelling as *Phallus impudicus* ▷▷. The smooth, dark spores measure 4.5–6.5 × 1.8–3 µm. Occurs on wood chips, on and around old stumps, and in similar places, in parks, deciduous forests and with conifers.

Mutinus ravenelii ▽ has red colours under the spore mass and normally also down the stem; it mainly occurs in gardens. *Mutinus elegans* ⨯ is very pointed, has vivid orange colours on the stem and the spore mass is even less well delimited.

Widespread and common; mainly June–January.

Mutinus ravenelii is a slender stinkhorn that tapers towards the top, does not have a well-delimited 'head', and has red colours under the olive-black spore mass; it also usually has red tinges down the stem. The witch's egg is slender and white, and has red colours when sectioned. Not as foul-smelling as *Phallus impudicus* ▷▷. The dark, sooty spores measure 5–7 × 1.8–2.5 µm. Sometimes occurs in large troops, typically on compost and disturbed soil in gardens and parks.

Mutinus caninus △ is ± orange under the spore mass.

Rare and meteoric in its occurrence – probably introduced from North America; June–October.

Jacques Landry

Puffballs and similar gasteroid fungi

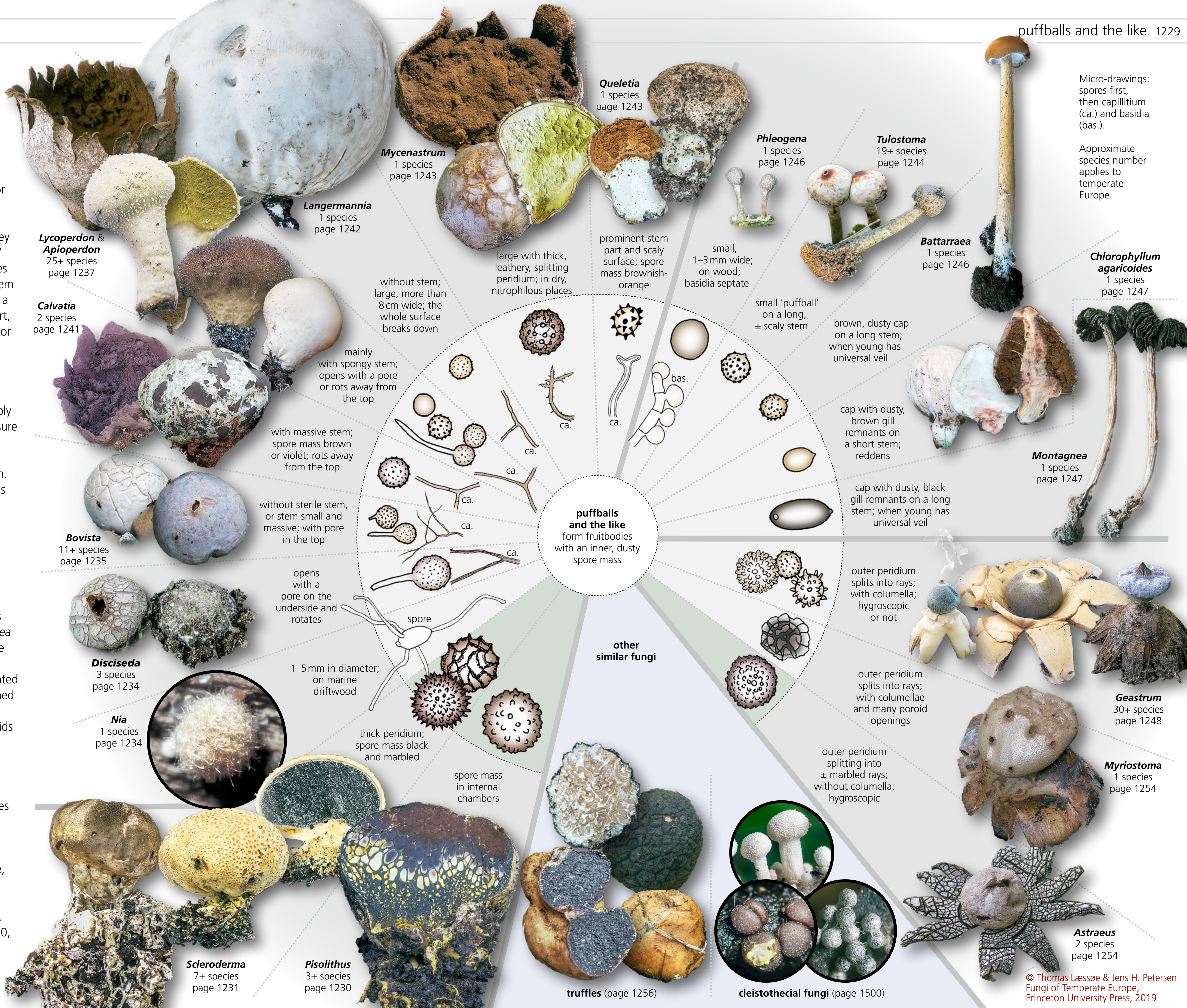
This form group includes basidiomycotes where the spores are produced inside the fruitbody and form a powder at maturity. The species may either be ball-shaped, with or without a stem, or have a star-like appearance when mature. The latter may open and close depending on moisture – they are hygroscopic. The surface 'skin' is termed a peridium. Some species have a sterile elongation of the stem within the spore-containing ball – a columella. Others may have a short, wide stem, which can be massive or have spongy flesh.

The spores are hydrophobic and dispersed by the splash from raindrops. Almost all species have dark, thick-walled spores – probably an adaptation to prolonged exposure to sun and wind. The spores may be mixed with elastic, branched, thick-walled hyphae – a capillitium. A spore mass with all elements it is termed a gleba.

Traditionally, all the species included here were placed in the artificial class *Gasteromycetes*, along with the bird's nest fungi, stinkhorns and basidiomycote truffles. Phylogenetically the majority belong within the agarics (*Agaricales*). *Battarraea*, *Montagnea* and *Chlorophyllum agaricoides* are intermediate types that in some respects look similar to closely related agarics, but the gills are transformed to a dusty spore mass at maturity. Such forms are also called secotioids after the genus *Secotium*, where they were formerly placed.

OTHER SIMILAR FUNGI:
– truffles have tuber-like fruitbodies that develop below ground (page 1256).
– cleistothecial fungi are ascomycotes with tiny, 0.2–3 mm wide, closed fruitbodies (page 1500).

FURTHER READING: 92, 134, 135, 136, 137, 138, 142, 156, 162, 241, 320, 365.

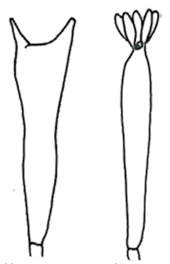


Truffles

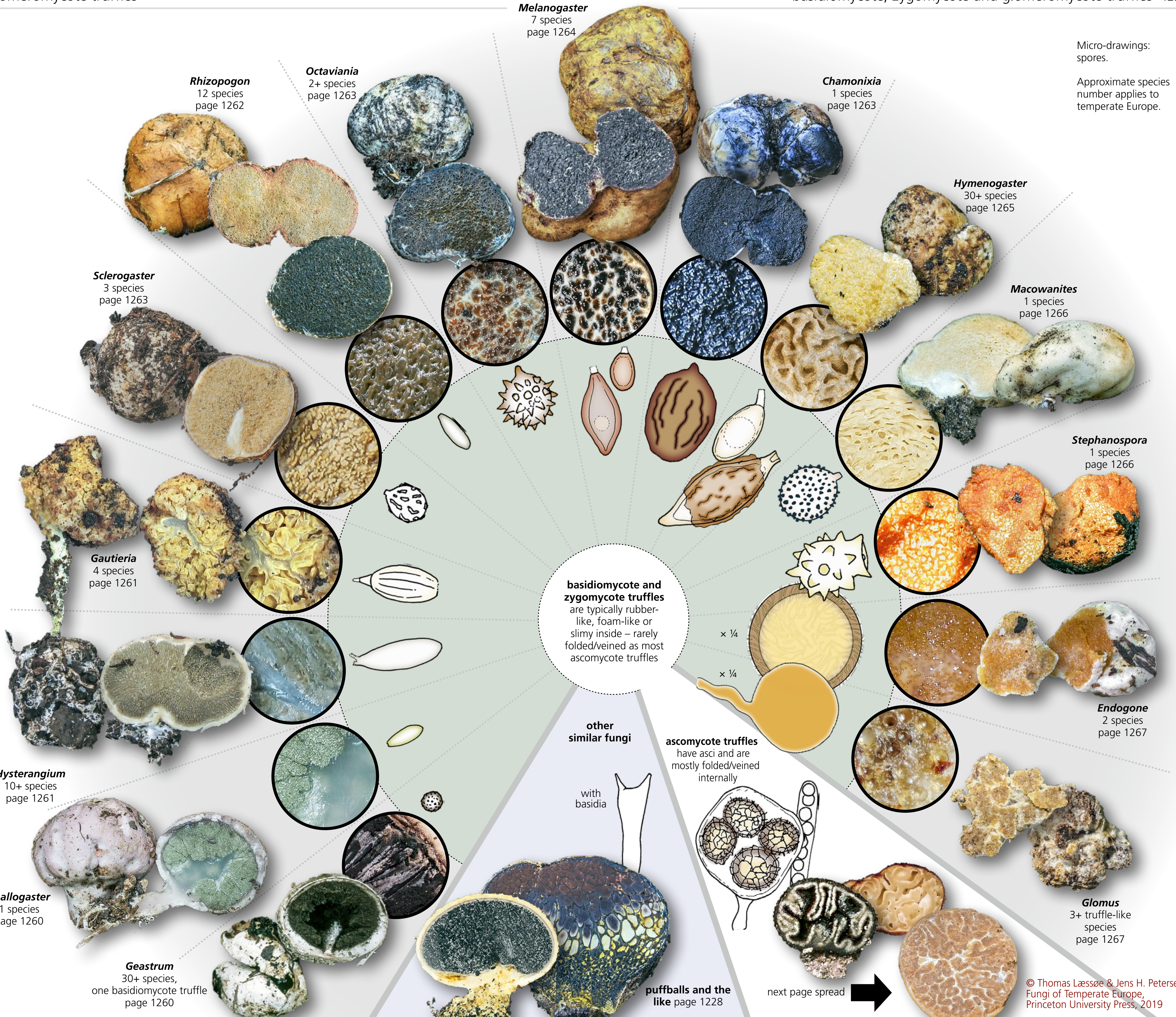
Truffles constitute a form group where the tuber-like fruitbodies are formed ± underground (hypogaeus) and spore dispersal is passive. This strategy has arisen multiple times during the evolution of the fungal kingdom, both amongst the *Ascomycota*, *Basidiomycota* and *Zygomycota* and within the *Glomales* (A-mycorrhiza-forming fungi), where truffle-like asexual structures can be found. The fungal wheels shown here have the basidiomycote and other non-ascomycote truffles on the first page spread and the ascomycotes (the 'true truffles') on the second.

Almost all truffles are ectomycorrhizal. They are dispersed by animals, and various mammals are attracted by the pungent odours. Boar, deer, rodents, *etc.* dig the fruitbodies out of the soil and eat them. Some rodents hoard truffles. Spores from some of the species tolerate passage through the gut. The odours vary from species to species, and some may resemble pheromones. It is probably compounds of the latter nature that make true truffles an exclusive ingredient in fine cuisine.

The spores are formed internally and the mechanism for active release has been lost. Within the basidiomycote truffles this means that the sterigmata on the basidia and the apiculus on the spores are absent or have changed, and that the spores are typically more symmetrical than in basidiomycotes with active dispersal. Within the ascomycotes the cylindrical ascus has typically evolved into a ± balloon-like shape without special structures, but in some species the cylindrical shape has been maintained. The ascospores tend to be extremely large (20–50 µm).



False truffle basidia: left, a 2-spored basidium from *Hymenogaster*; right, a 6-spored basidium without sterigmata from *Hysterangium*.



How to find truffles (truffling)

Some truffles may form fruitbodies at soil level with the top clearly visible; this is often the case with, for example, species of *Rhizopogon* and *Choiromyces*. However, as the majority form completely immersed fruitbodies in litter or rotten wood, or in soil down to 10–15 cm, sometimes deeper, they have to be dug out (*e.g.* with a small hand rake). Successful truffling requires a certain 'feel' for the ecology of the species. One simple prerequisite is the presence of suitable mycorrhizal partners, mainly trees and shrubs, *e.g.* *Corylus*, *Tilia*, *Fagus*, *Quercus* or ectomycorrhizal conifers. Relatively light, mull soils can often be rewarding to rake through, mainly in places with a warm microclimate. Rake the surface and keep an eye out for any tuberous object (alas, many will be fungal primordia, pebbles, old nuts, *etc.*). Some truffles form potato-sized fruitbodies, but many are small, down to the size of a pea. If you think you have found a truffle, cut it through with a sharp blade and check the internal structure with a hand lens; if veined or spongy you are in luck.

A shortcut can be taken by looking out for animal scrapes, *e.g.* from deer or squirrels – or, even better, train a dog!

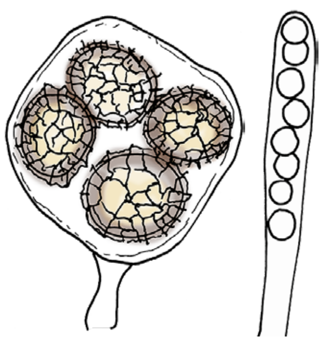
Other similar fungi:

– witch's eggs may look similar but do not grow underground (page 1222).

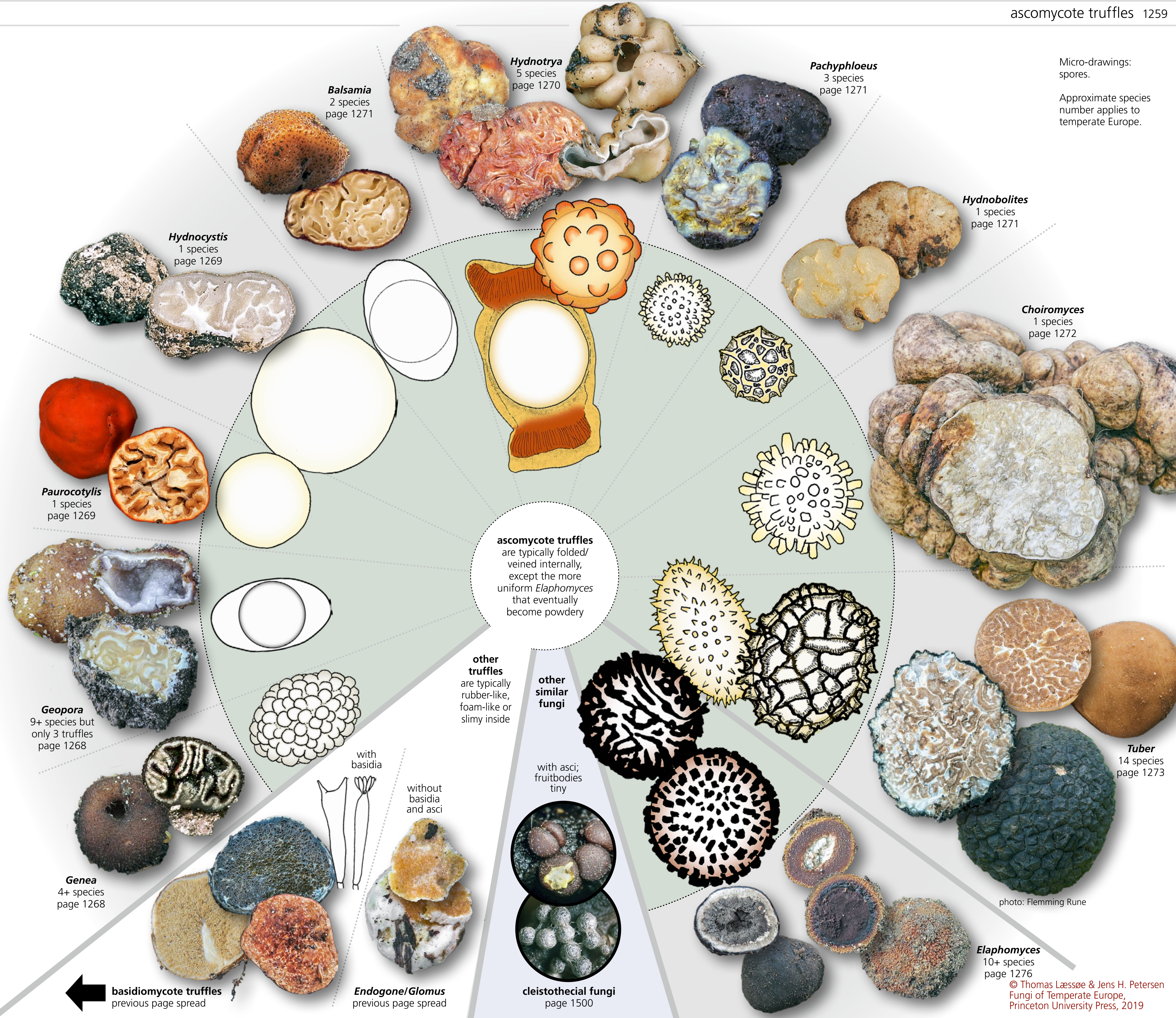
– puffballs and the like typically become dusty at maturity and are normally not immersed in soil (page 1228).

– cleistothecial fungi produce tiny fruitbodies with tiny asci (page 1500).

Further reading: 7, 98, 163, 197, 238, 239, 240, 303, 317, 318.



Types of truffle asci: left, a balloon-shaped tytpe from *Tuber aestivum*; right, a cylindrical ascus from *Hydnocystis*.



Operculate cup fungi

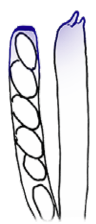
The operculate cup fungi are characterized by a small lid (an operculum) at the top of the asci, and all operculate species are classified in the order *Pezizales*. The open fruitbodies (apothecia, see page 30) have the hymenium on the surface/inner side of the cap or cup. They are often rather large and may be ± cup-shaped, either have or lack a stem or, as in the morels, be more folded or pitted.

The hymenium is a mixture of asci and paraphyses. The spores are mostly large and may be ornamented with *e.g.* a raised reticulum or with warts or spines. The ends of the spores may have appendages.

Some species are ectomycorrhizal, while others are decomposers of dead organic material, *e.g.* dung, wood or debris. A third group is parasitic, mainly on bryophytes and hepatics.

The dung-inhabiting (coprophilous) species often produce very small fruitbodies compared to the ectomycorrhizal species. The smallest fruitbodies are found in the genera *Ascozonus*, *Coprotus* and *Thelebolus* and can be less than 0.5 mm in diameter. The species in these three genera also have aberrant asci, where the top cracks instead of opening with a lid, and are classified in an order of their own, the *Thelebolales*.

Other similar fungi:
– inoperculate cup fungi have asci with an internal plug-like structure or no structure at all. They are mostly smaller, typically 0.5–5 mm in diameter, and mainly occur on dead herbaceous stems, fallen leaves or dead wood. Club-shaped inoperculate cup fungi (page 1348) may resemble small morels (page 1280) and often occur on soil.



Amyloid asci with lid in a *Peziza* before and after spore discharge.

Morels and the like

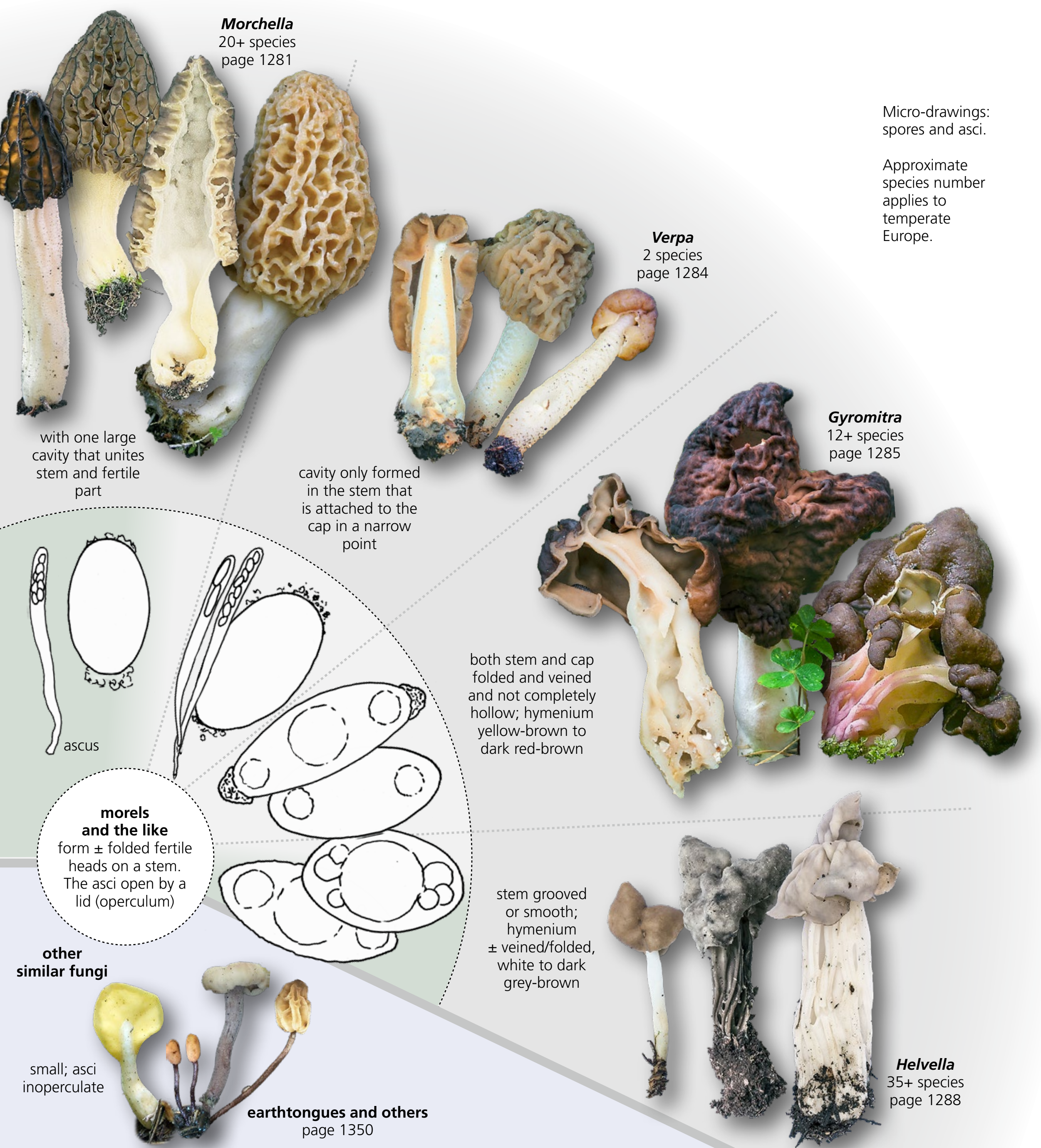
All species belong to the operculate cup fungi, *i.e. Ascomycota*, and have an exposed hymenium and asci that open with a lid (an operculum). All have inamyloid asci. They produce the largest fruitbodies (apothecia) within the ascomycotes – species of *Morchella* ▷ and *Gyromitra* ▷▷ can reach more than 20 cm in height. The hymenophore is often highly folded, resulting in the hymenium having a large surface area.

Morchella may form mycorrhiza-like associations with plants, *e.g.* with *Rosaceae*, *Ulmus* or herbs. *Gyromitra* is saprotrophic, while *Helvella* is ectomycorrhizal.

Other similar fungi:
– some species in the group 'earthtongues and the like' may look similar to tiny morels. These, however, have inoperculate asci (page 1350).

See also the main wheel, page 1278.

Further reading: 101, 180, 266, 301 328.



Morchella is a genus of large, operculate cup fungi with a pitted and hollow head on a hollow stem. The spores are large and smooth. The genus probably includes both mycorrhizals and saprotrophs.

●● ***Morchella esculenta*** is a large, at maturity ± buff *Morchella* with a hymenophore of large, rather regular honeycomb-like cells. The hollow top may be conical or almost globose, and the stem length and thickness is very variable. It has a pleasant, spicy odour. The smooth spores measure 18–22 (–27) × 12.5–14 µm, and they have numerous external drops at the poles but none internally. Occurs on rich, ± calcareous soils – often with *Ulmus*, but also found with *e.g. Fraxinus* and *Populus*; mycorrhizal.

Morchella esculenta is part of difficult species complex. *Morchella vulgaris* ▽ is darker with more irregular hymenophoral cells. *Morchella americana* ⋉, found in central Europe, was probably recently introduced from North America. *Morchella steppicola* ⋉ occurs in the steppes of Eastern Europe.

Widespread, occasional; April–June.

●● ***Morchella vulgaris*** is a relatively large to large, rather dark *Morchella* with a hymenophore that has a rather irregular honeycomb-like pattern of cells with thick walls. The smooth spores measure 18–22(–27) × 12.5–14 µm and have numerous external drops at the poles, but none inside. Occurs on ± calcareous soil in deciduous forests, parks, gardens and dunes, may occur with a range of partner trees, *e.g. Crataegus*, *Malus*, *Fraxinus* and *Sorbus*; mycorrhizal.

Morchella americana ⋉, which was apparently introduced to Europe from North America, is very similar and probably requires sequencing in order to confirm identification. *Morchella esculenta* △ is typically paler and the cells in the hymenophore are more regular.

Widespread, occasional; mainly April–June.

Operculate cup fungi with dull colours

Apothecial ascomycotes with disc- to cup-shaped apothecia, with or without stems, and with whitish, greyish, brownish, violet, or black hymenia. The asci have a lid (an operculum) or, in *Thelebolus* and *Ascozonus,* a cracking top.

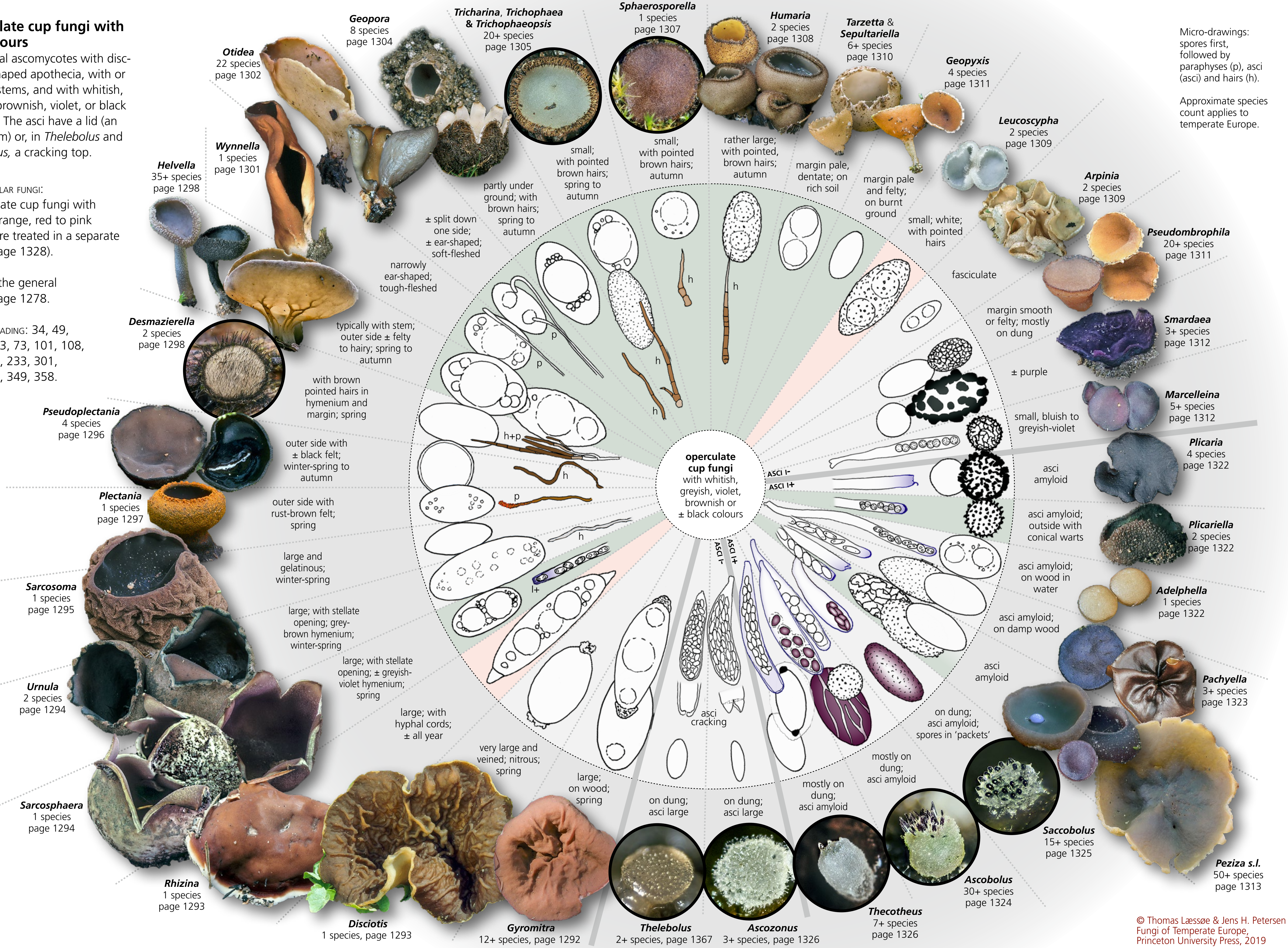
OTHER SIMILAR FUNGI:
– operculate cup fungi with yellow, orange, red to pink colours are treated in a separate wheel (page 1328).

See also the general wheel, page 1278.

FURTHER READING: 34, 49, 51, 52, 53, 73, 101, 108, 109, 118, 233, 301, 310, 329, 349, 358.

Micro-drawings: spores first, followed by paraphyses (p), asci (asci) and hairs (h).

Approximate species count applies to temperate Europe.



Yellow, orange, red to pink operculate cup fungi

Fungi with cup- to goblet-shaped or flattened apothecia, yellow, orange, red or pinkish hymenium, and asci with a lid (an operculum) or, in the genus *Coprotus*, with a slit-like opening mechanism. All genera, apart from *Iodophanus* and *Peziza*, have inamyloid asci.

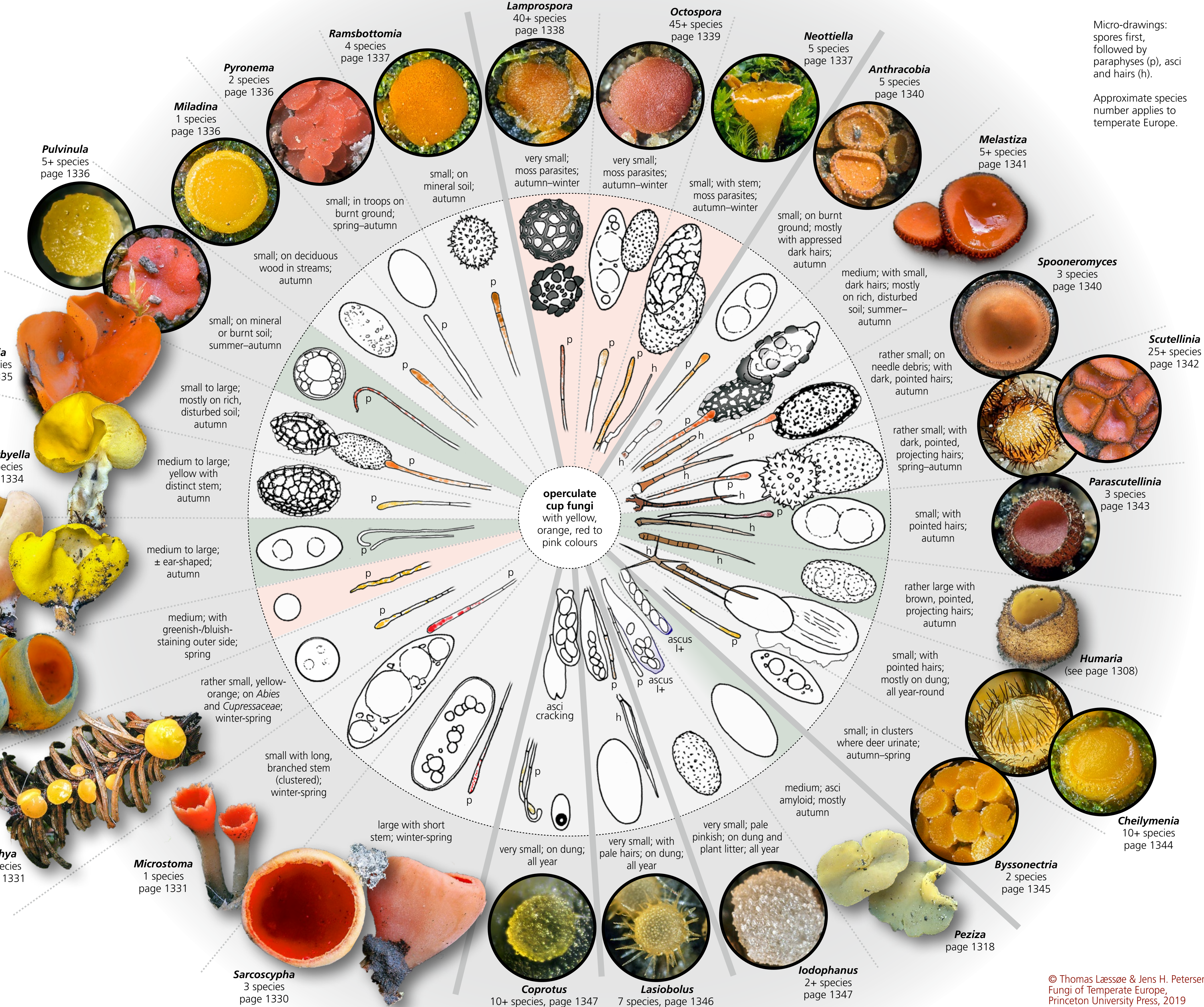
OTHER SIMILAR FUNGI:
– operculate cup fungi with whitish, greyish, brownish, violet or black hymenia are found in the wheel on page 1290.

See also the general wheel, page 1278.

FURTHER READING: 33, 34, 39, 49, 73, 101, 119, 198, 199, 200, 233, 292, 359, 360, 361, 363, 364.

Micro-drawings: spores first, followed by paraphyses (p), asci and hairs (h).

Approximate species number applies to temperate Europe.



Inoperculate cup fungi

The inoperculate cup fungi is a form group of ascomycetes with open fruitbodies (apothecia) where spore release is mostly controlled by an inner, cork-like structure at the ascus tip. The name refers to the lack of an operculum (a lid on the top).

The apothecia are mostly small (less than 2 mm wide) and cushion- or disc-shaped to cupulate, and numerous species occur on wood or herbaceous stems. A few genera produce larger or ± club-shaped apothecia. Species in the *Sclerotiniaceae* produce apothecia from overwintered sclerotia; many of these are plant parasites.

The hymenium is in most cases made of asci and paraphyses. The spores are typically hyaline, small and smooth.

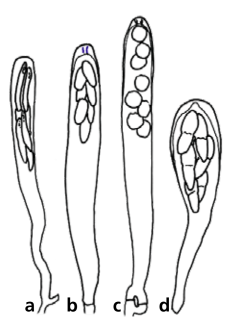
This form group is very large with nearly 300 genera and perhaps around 1,000 species in temperate Europe. The generic delimitation will undoubtedly undergo many changes in the coming years, and many more species will be described. Here we have included 139 genera with 256 species.

Other similar fungi:

– the operculate cup fungi have asci that open with a lid (an operculum). The fruitbodies are mostly larger and many species occur on soil or wood. A group of species on dung have very small apothecia (page 1278).

– the apothecial lichens may have fruitbodies that can look very similar to species in this form goup, but most have obvious thalli with algae or cyanobacteria (page 1484).

– cyphelloids are small basidiomycetes with mainly downturned, cupulate or ear-shaped fruitbodies (page 1076).



asci with a: simple top; b: cylindrical apical apparatus and simple base; c: cylindrical apical apparatus and crozier at the base; d: thick-walled top.

Earthtongues and the like

This form group includes the species of inoperculate cup fungi that have clavate, tongue-shaped, spatulate or morel-like fruitbodies.

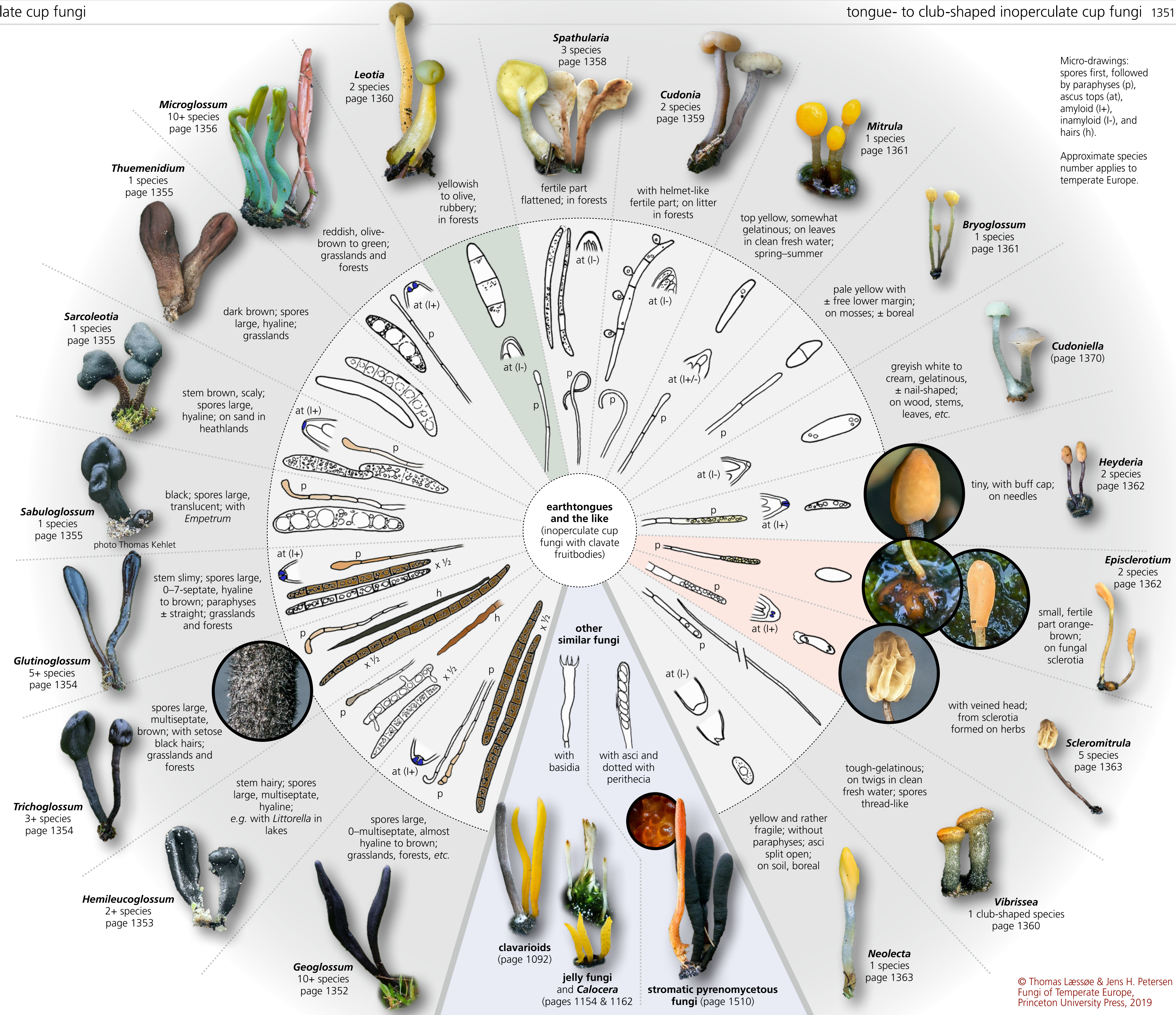
Almost all species in the group have asci with an internal apparatus near the tip that is blown out and inverted during spore ejection. This apparatus often stains blue in iodine. The genus *Neolecta* (page 1363) deviates by having asci that split open (no apparatus) and by the lack of paraphyses among the asci.

Many species are decomposers but earthtongues, for example, possibly form biotrophic associations with plants in the same way as the hygrocyboid fungi (*Hygrocybe* and others) are thought to do (page 18).

Other similar fungi:
– clavarioids may have very similar fruitbodies but are basidiomycetes, *i.e.* the spores form on basidia (page 1092).
– jelly fungi and *Calocera* may be clavate in shape but are tougher and have septate or tuning fork-shaped basidia (page 1154 & 1162).
– stromatic pyrenomycetous fungi such as, for example, *Cordyceps*, *Trichoderma* and *Xylaria*, have the flesh filled with perithecia (see page 30) and the openings can be seen as small dots on the surface (page 1510).
– long-stemmed inoperculate cup fungi have a rather well-defined disc with hymenium (page 1404).

See also the general wheel, page 1348.

Further reading: 14, 21, 49, 101, 166, 167, 168, 277.



Micro-drawings: spores first, followed by paraphyses (p), ascus tops (at), amyloid (I+), inamyloid (I-), and hairs (h).

Approximate species number applies to temperate Europe.

Large, gelatinous inoperculate cup fungi

A form group with often quite large, discoid, turbinate or brain-like, highly gelatinous apothecia. The spore release is controlled by an internal, cork-like structure in the ascus top. The species in this group are predominantly wood-decayers.

Other similar fungi:

– grades into the group of small, gelatinous, inoperculate cup fungi. It can be difficult to determine whether or not a tiny cup fungus has gelatinous matter in the tissues, and it is important to check the wheels for both the short- and long-stemmed inoperculate cup fungi (pages 1404 & 1426).

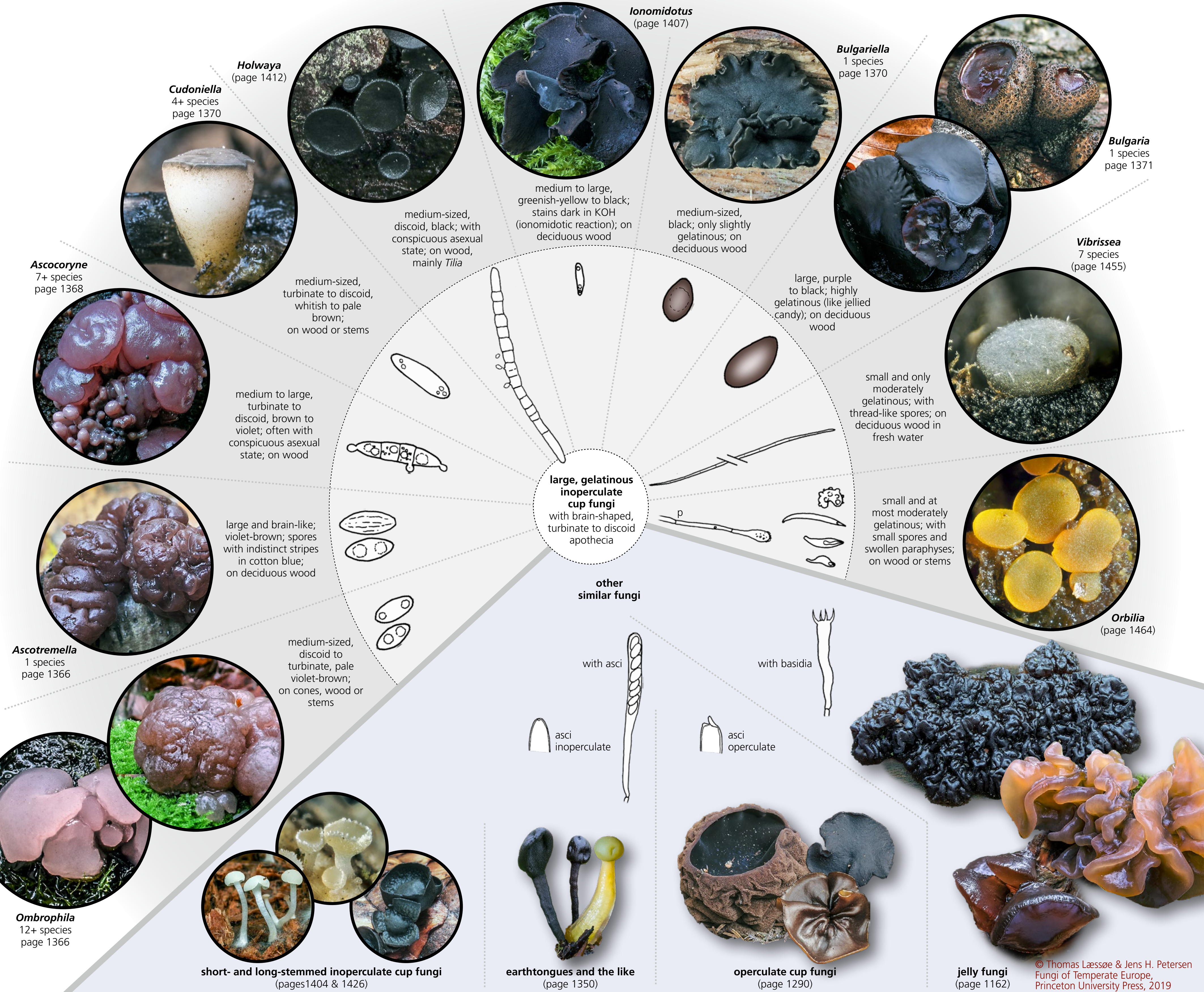
– gelatinous, tongue-shaped species are included on page 1350.

– gelatinous, operculate cup fungi are included on page 1290.

– jelly fungi have basidia, see page 1162. However, they can superficially resemble species of *Ascotremella* and *Ombrophila* and microscopy may be required.

See also the general wheel, page 1348.

Further reading: 21, 49.



Micro-drawings: spores outermost, followed by paraphyses (p).

Approximate species count applies to temperate Europe.

Downy to hairy inoperculate cup fungi

This form group of small inoperculate cup fungi has the outer side, and especially the margin, covered by projecting hairs. They are mainly decomposers and occur predominantly on herbaceous stems, fallen leaves, cones and wood.

The group contains many genera, and the appearance of the hairs (the shape, size, colour, crystal-covering, guttulation, *etc.*) is a very important distinguishing character. Some of the more distinctive species can be recognized in the field, but identification mostly requires the use of a microscope.

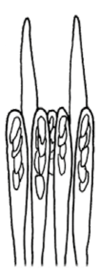
The majority of the species are classified within the *Hyaloscyphaceae*, and many have long paraphyses with lanceolate or tapering tips that project above the asci (see figure below).

Other similar fungi:

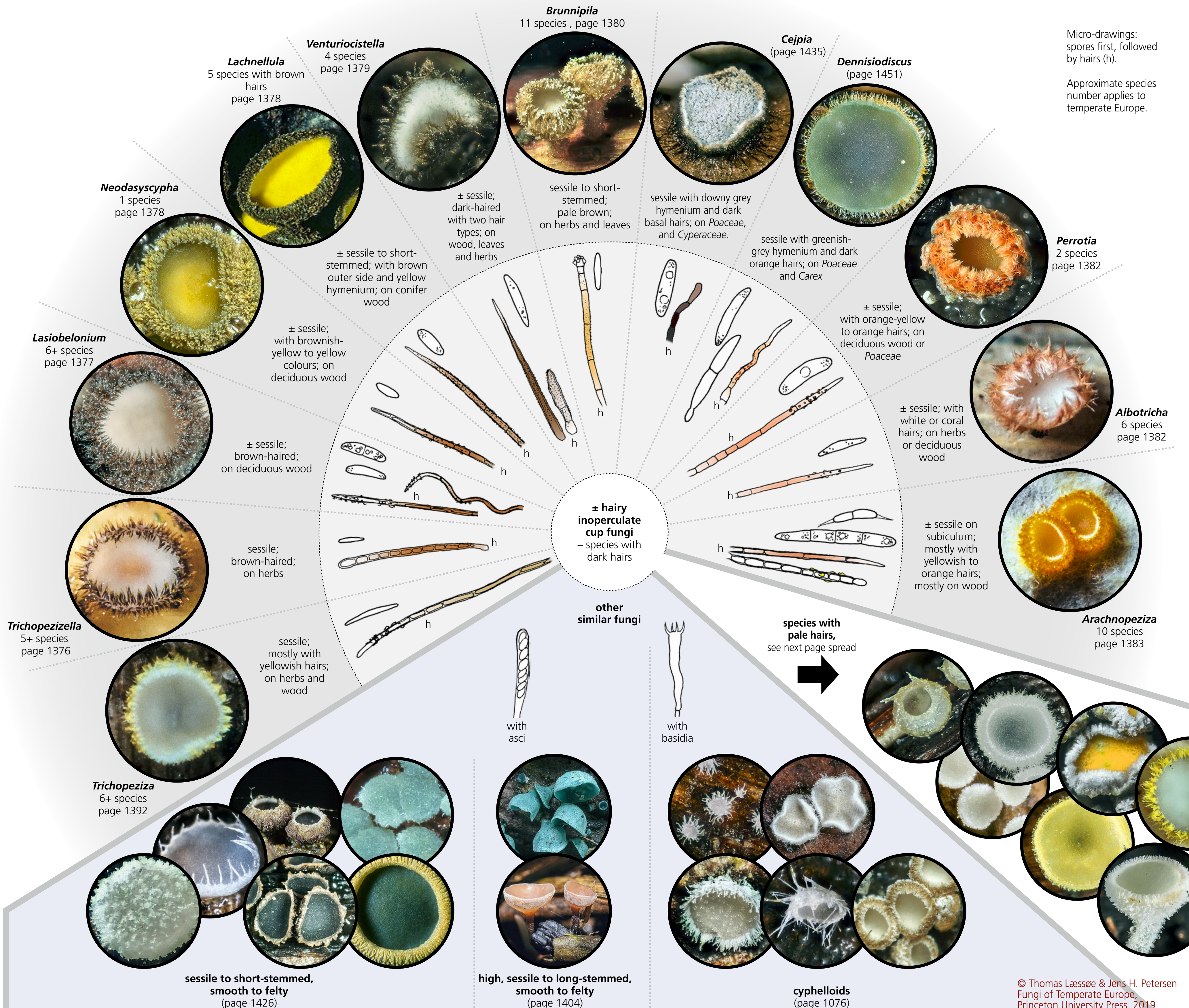
– cyphelloid fungi (page 1076) have small, hanging fruitbodies. They are *basidiomycotes* and can be recognized by their basidia and spore morphology – the spores having a small appendage (apiculus) where they were attached to the sterigmata. They are often not as elegant as the hairy inoperculate cup fungi and the hairs are more disorderly.

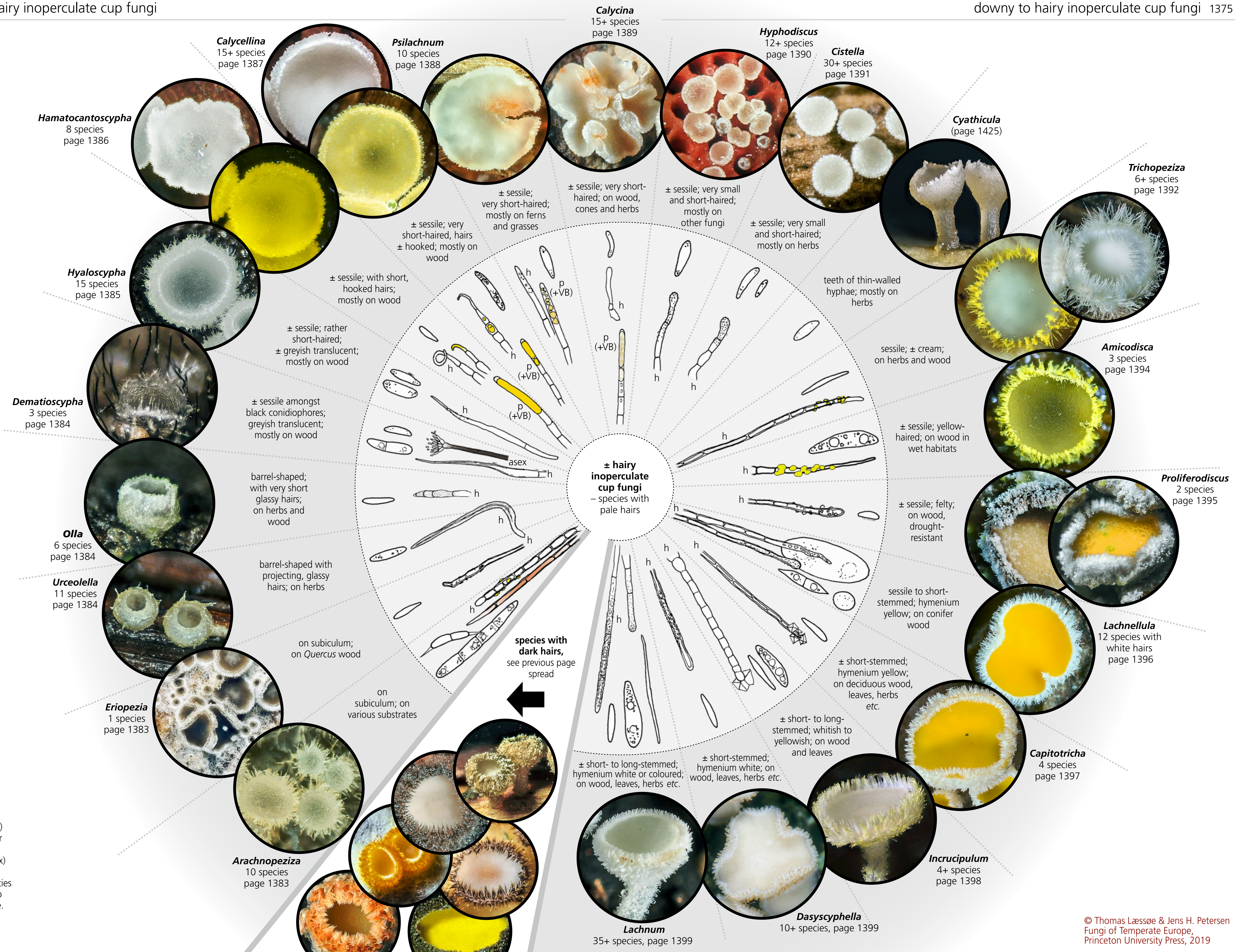
– some other inoperculate cup fungi have hairs but they are short and adpressed, making the apothecia look felty rather than hairy (a hand lens or dissecting microscope is required) – see the general wheel to the inoperculate cup fungi, page 1348.

Further reading: 21, 22, 23, 49, 78, 101, 115, 116, 160, 253, 319.



A typical hymenium in the genus *Lachnum* with asci and lanceolate, projecting paraphyses.





Micro-drawings: spores first, followed by hairs (h), paraphyses (p) refractive vacuolar bodies (VB) and asexual state (asex)

Approximate species number applies to temperate Europe.

High or long-stemmed, smooth to felty inoperculate cup fungi

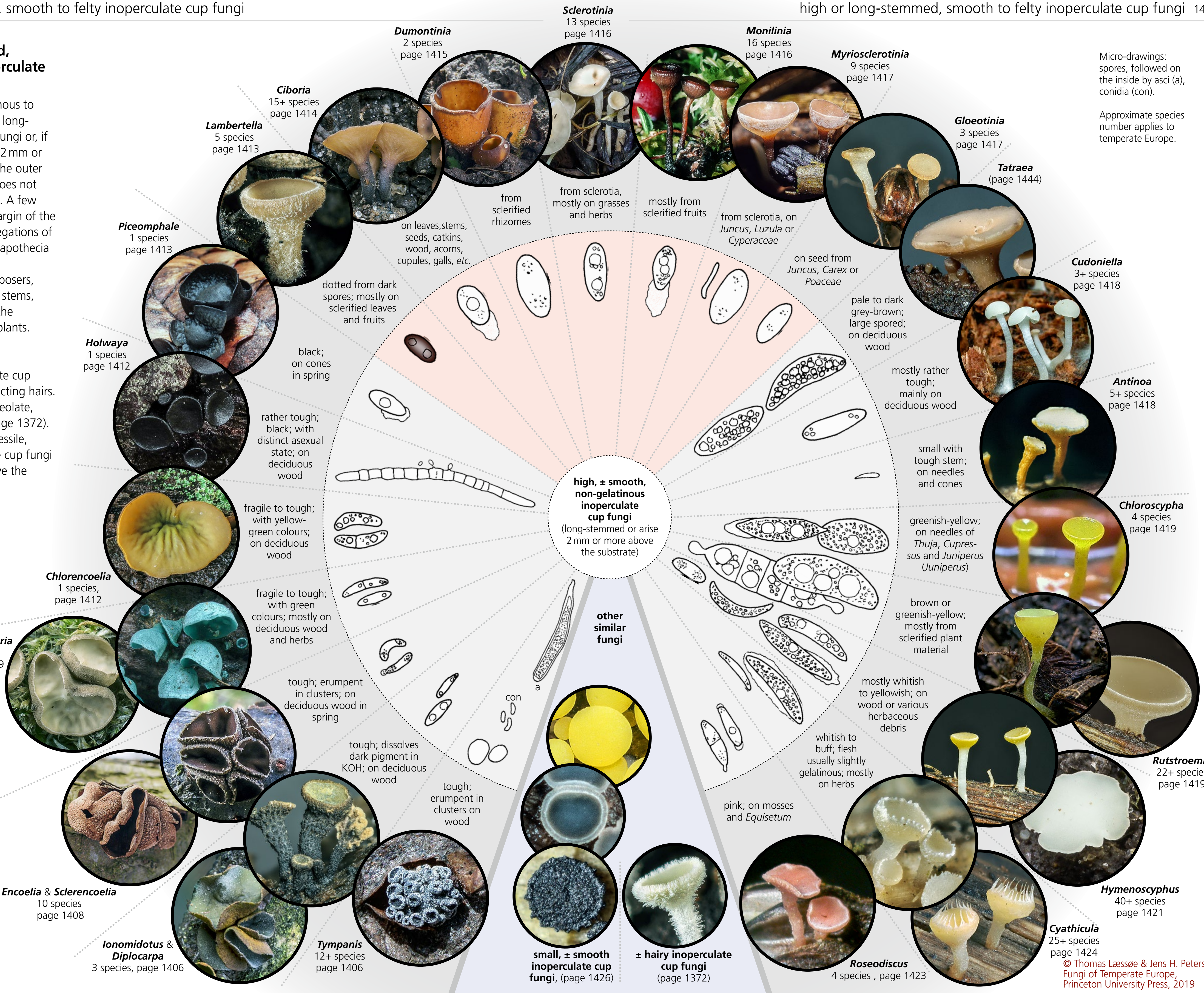
A form group of non-gelatinous to slightly gelatinous, distinctly long-stemmed inoperculate cup fungi or, if short-stemmed, growing to 2 mm or more above the substrate. The outer side is smooth to felty but does not have projecting hyphal hairs. A few species have teeth at the margin of the apothecia made up of aggregations of hyphae. Some species form apothecia from sclerotia.

Some species are decomposers, *e.g.* of wood or herbaceous stems, while others – members of the *Sclerotiniaceae* – parasitize plants.

Other similar fungi:
– downy to hairy inoperculate cup fungi are covered by ± projecting hairs. Many species also have lanceolate, ± projecting paraphyses (page 1372).
– small, short-stemmed to sessile, smooth to felty inoperculate cup fungi arise to less than 2 mm above the substrate (page 1426).

See also the general wheel, page 1348.

Further reading: 19, 21, 49, 59, 72, 78, 95, 101, 252, 267, 354, 362.



Micro-drawings: spores, followed on the inside by asci (a), conidia (con).

Approximate species number applies to temperate Europe.

Low, smooth to felty inoperculate cup fungi

This group includes sessile to very short-stemmed, less than 2 mm high, inoperculate cup fungi with an outer side and margin that is smooth to felty or rarely toothed, but which never has projecting, hyphal hairs. Large genera in the group include *Mollisia* and *Orbilia*.

Other similar fungi:
– long-stemmed or high (growing to 2 mm or more above the substrate), ± smooth inoperculate cup fungi (page 1404).
– downy to hairy inoperculate cup fungi may be sessile to long-stemmed but have ± projecting hairs. Many species also have lanceolate, ± projecting paraphyses (page 1372).
– erumpent inoperculate cup fungi are typically ± immersed in the substrate from where the apothecia emerge by splitting the substrate or by pushing a lid aside. The fruitbodies can often close again during dry spells and reopen when wetted (page 1468).

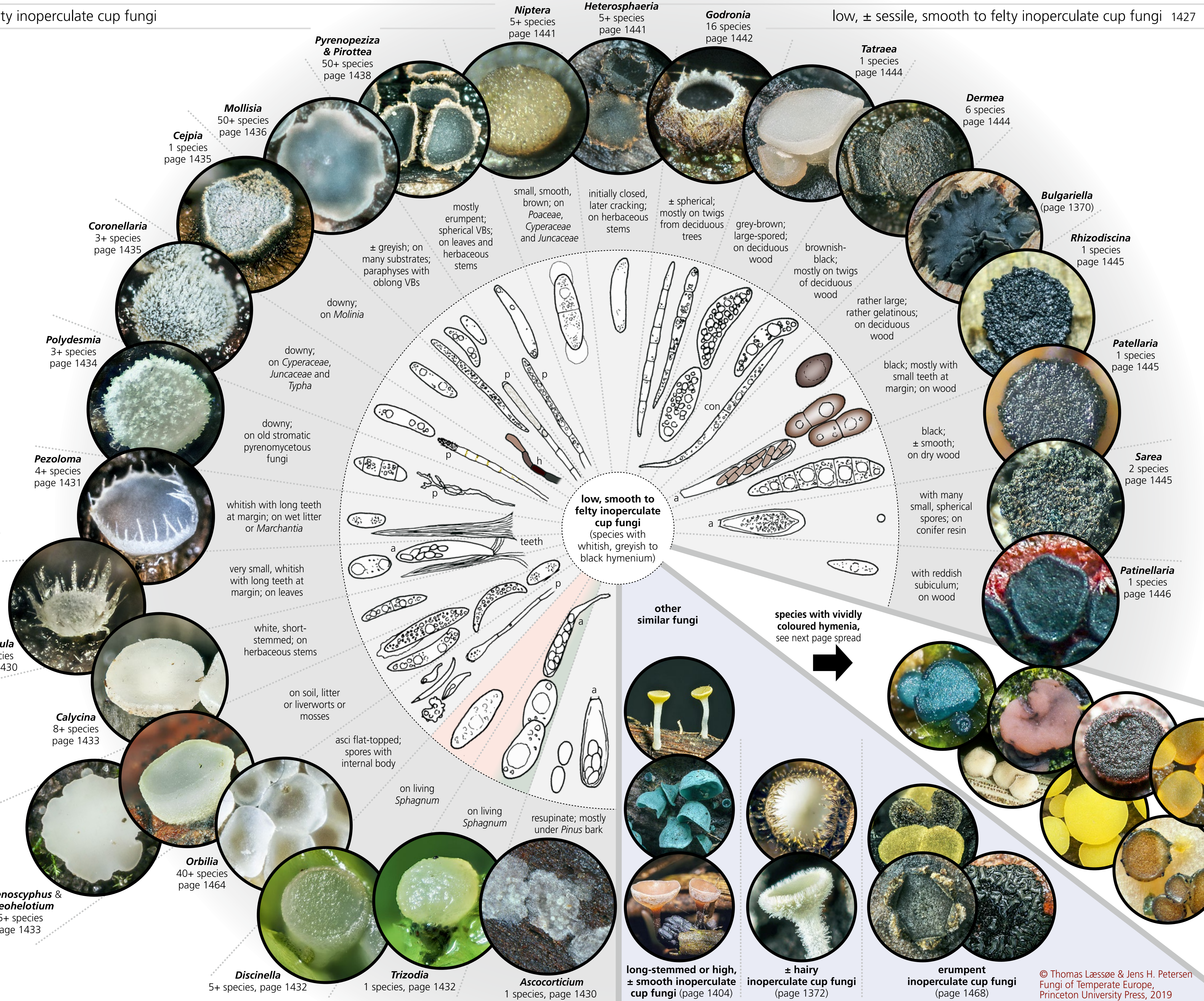
See also the general wheel, page 1348.

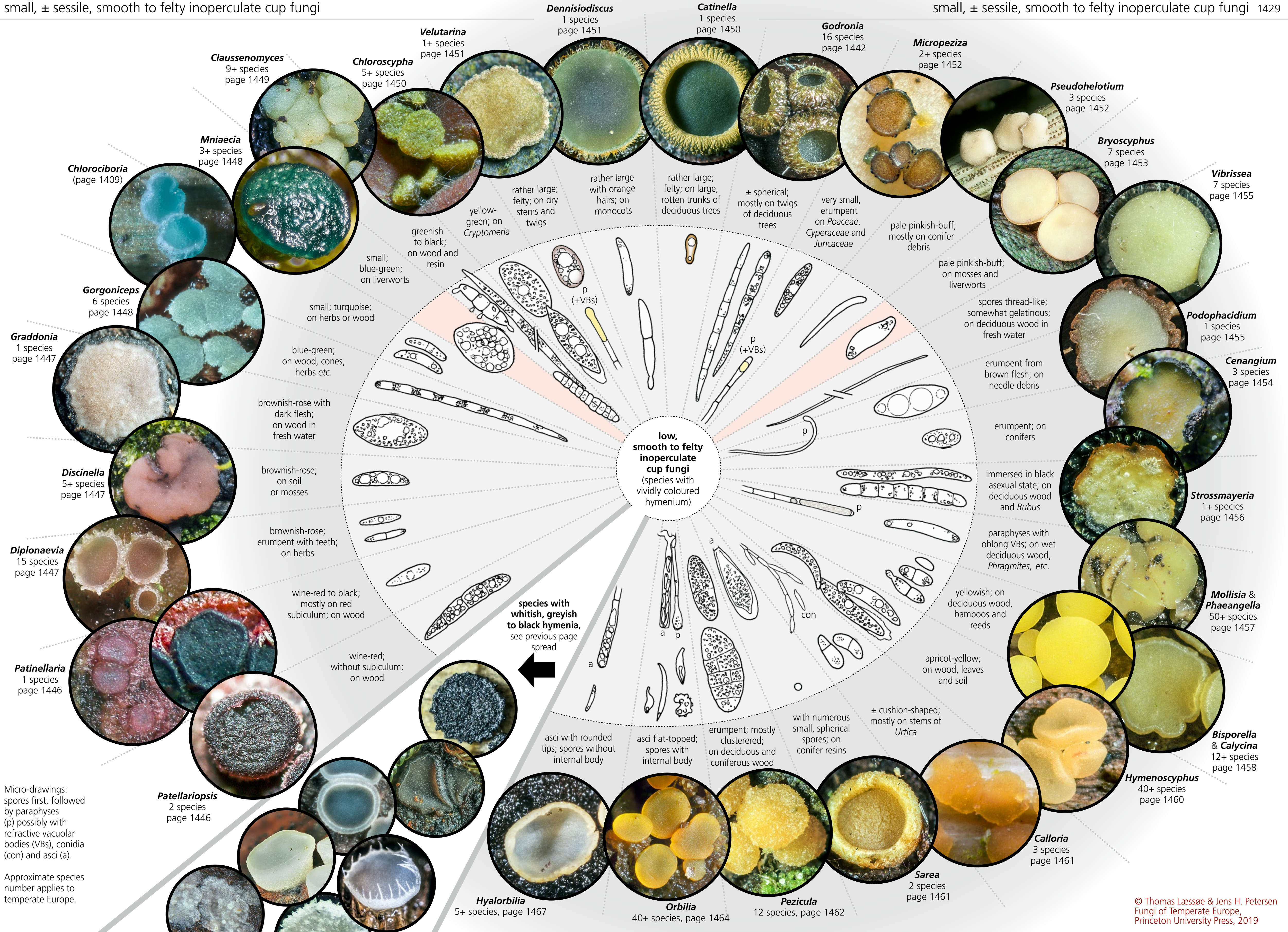
Further reading: 20, 21, 49, 78, 79, 153, 177, 210, 211, 212, 213, 214, 216, 286, 291, 334.

Continued on next page spread . . .

Micro-drawings: spores first, followed by paraphyses (p) possibly with refractive vacuolar bodies (VBs), conidia (con) and asci (a).

Approximate species number applies to temperate Europe.





Micro-drawings: spores first, followed by paraphyses (p) possibly with refractive vacuolar bodies (VBs), conidia (con) and asci (a).

Approximate species number applies to temperate Europe.

Erumpent inoperculate cup fungi

A form group of inoperculate cup fungi that develop fruitbodies (apothecia) within the substrate (typically in stems, leaves or wood). At maturity the apothecia breaks through the surface (erumpent). They may be disc-shaped or elongated and are often surrounded by torn parts of host tissue, which is sometimes evident as distinct teeth or 'lips'. The teeth may involve both host and fungus tissue. Many species have a black, almost carbonous outer side.

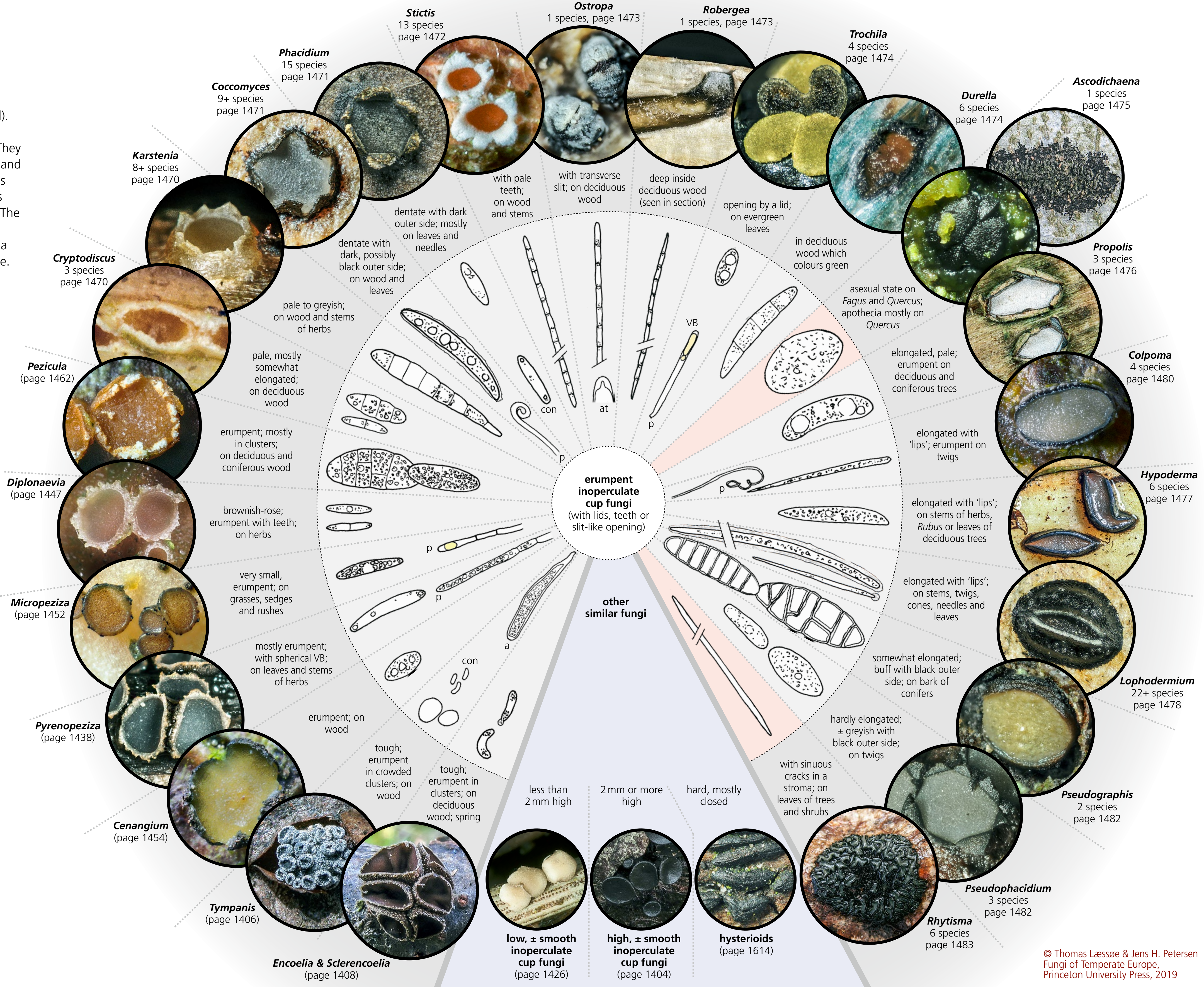
OTHER SIMILAR FUNGI:
– grades into the sessile, smooth inoperculate cup fungi (page 1426).
– some large, inoperculate cup fungi are also erumpent, but form higher fruitbodies (page 1404).
– hysteroids have a slit-like opening but are hard and the hymenium is rarely exposed (page 1614).

See also the general wheel, page 1348.

FURTHER READING: 18, 21, 49, 78, 139, 215, 297, 298.

Micro-drawings: spores first, followed by conidia (con), paraphyses (p), refractive vacuolar bodies (VB), asci (a) and ascus tops (at)

Approximate species number applies to temperate Europe.



Lichens

Lichenized fungi live in a mutualistic symbiosis with green algae and/or cyanobacteria that are able to perform photosynthesis. The algae/cyanobacteria (called the photobiont) provide the fungus with sugars and the fungus affords shelter for the photobiont in the form of a ± well-developed thallus (see page 19). Most species are perennial and slow growing.

Lecanoralean lichens are by far the largest group of lichens, with more than 1,500 species in temperate Europe. They are traditionally studied by lichenologists and are only briefly introduced on the following pages. When sexual, the lecanoralean lichens produce apothecia on a flattened, clavate or branched thallus. They have thick-walled asci with amyloid walls.

The calicioid lichens constitute an aberrant group that form tiny fruitbodies with a dusty spore mass on the top of a small stem (page 1494).

Pyrenolichens form perithecioid fruitbodies and belong to the bitunicate, pyrenomycetous fungi, pages 1615 and 1545.

Basidiolichens are lichenized basidiomycotes. They may be agarics, clavarioids or (in warmer climates) corticioids (pages 130 & 1114).

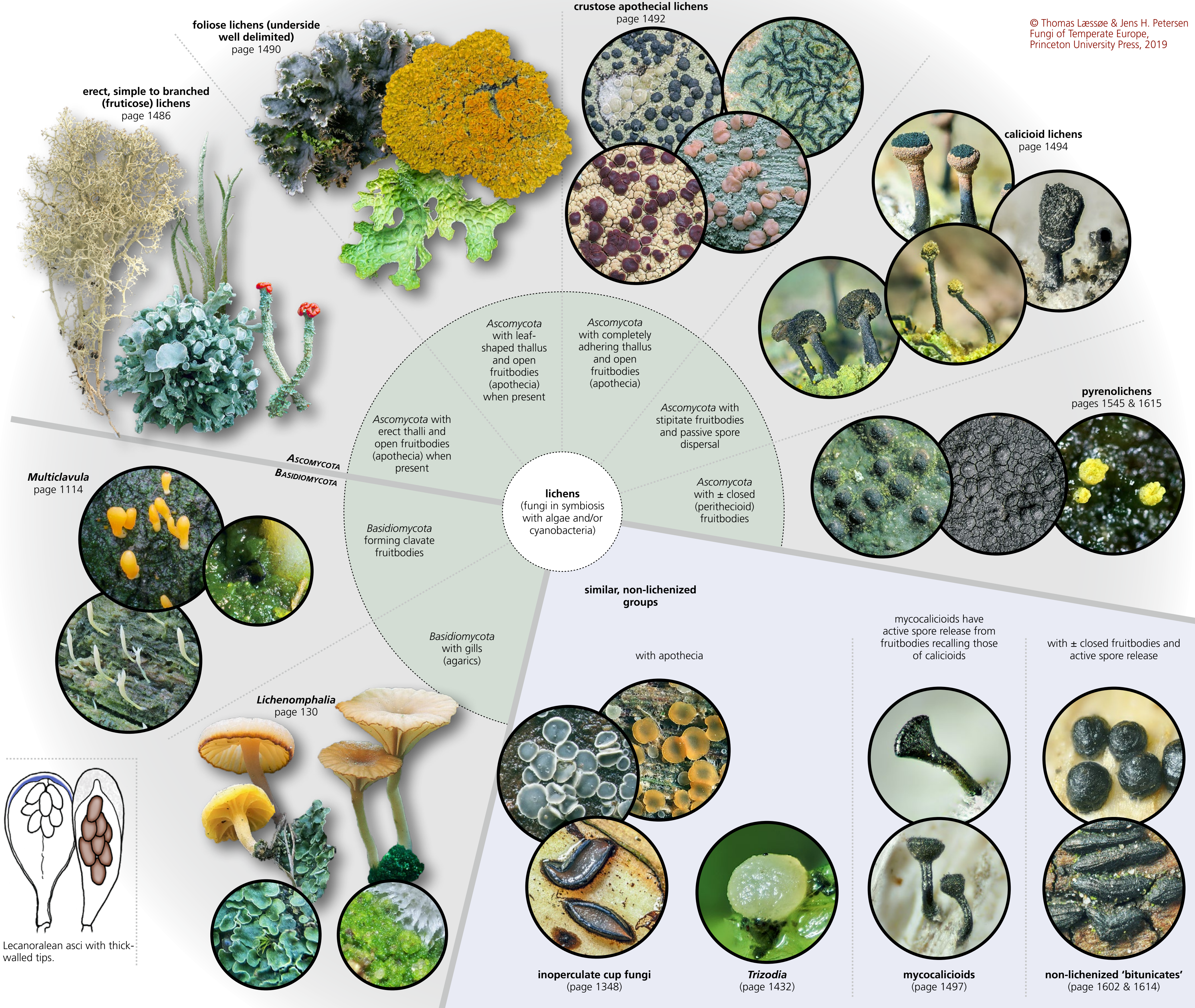
The most frequent photobiont is the green alga *Trebouxia*, more rarely *e.g.* the yellowish-green alga *Trentepohlia*. *Nostoc*, a genus of cyanobacteria, can also act or co-act as the photobiont, and can benefit the symbiosis by fixing nitrogen from the atmosphere.

Identification of lichens normally involves the use of a series of chemical characters but these are not covered here.

Other similar fungi:
– the inoperculate cup fungi have similar, small, discoid fruitbodies but usually much simpler asci (page 1348).
– *Trizodia* has a not fully understood symbiosis with *Sphagnum* and cyanobacteria (page 1432).
– mycocalicioids recall the calicioids but are not lichenized (page 1497)
– 'bitunicates' and hysterioids may recall crustose (crust-like) lichens (page 1602 & 1614).

Further reading: 302, 316, 355.

Lecanoralean asci with thick-walled tips.



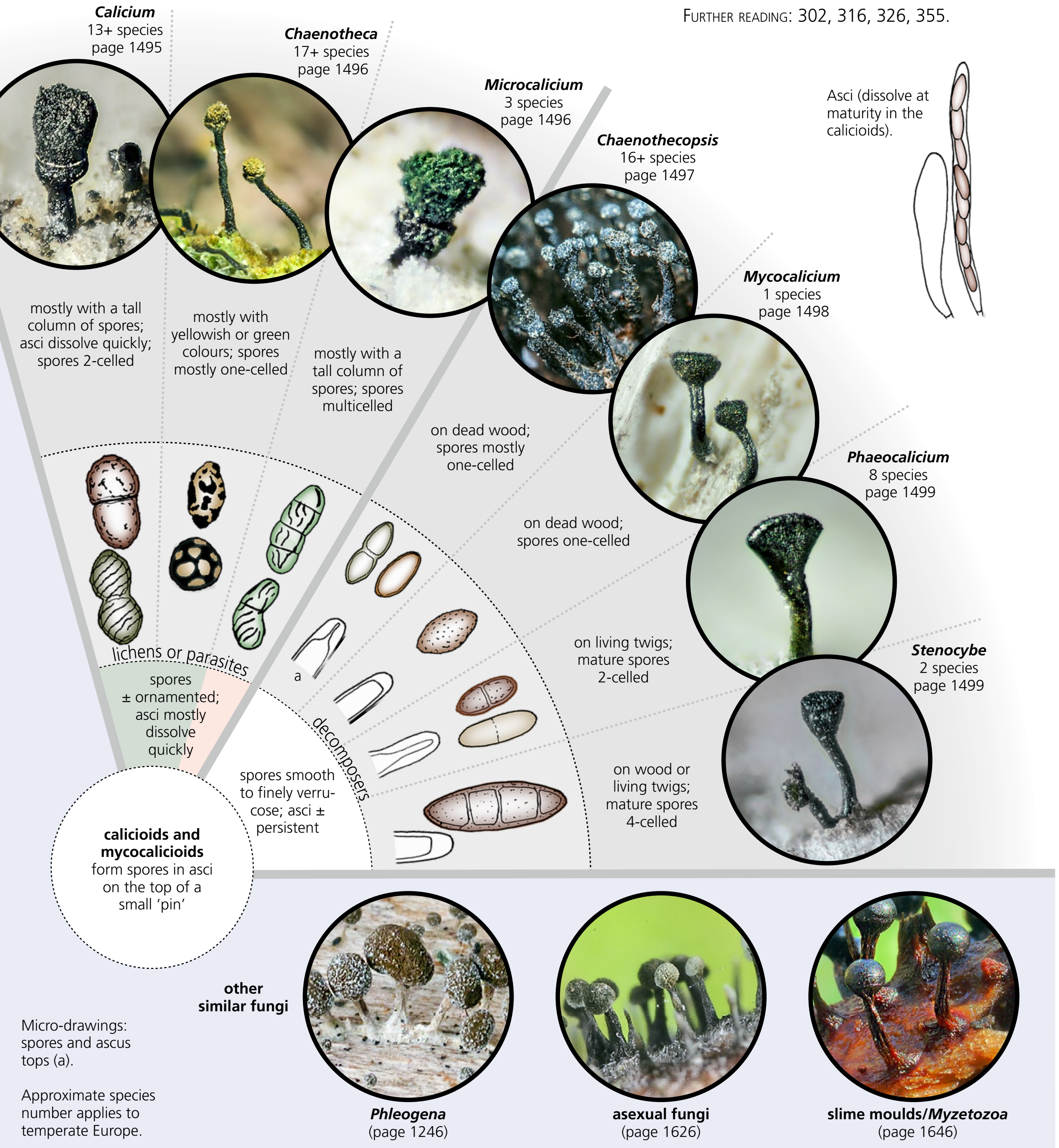
Calicioids and mycocalicioids

Calicioids and mycocalicioid fungi are two groups of distantly related ascomycotes with very similar, tiny, pin-shaped fruitbodies. In some species the spores are deposited in a powdery column on the top and passively dispersed. The calicioids live in a mutualistic symbiosis with green algae such as *Trebouxia*, *Stichococcus*, *Dictyochloropsis* and *Trentepolia*; the mycocalicioid fungi are decomposers.

Many species can be found on old, sun-exposed wood, but the small fruitbodies are easily overlooked; they are best found by using the sky as a background when inspecting potential substrates.

Other similar fungi:
– *Phleogena* has larger fruitbodies; it is a basidiomycote with transversely divided basidia (page 1246).
– asexual fungi may form very similar structures (page 1626).
– many slime moulds may look similar but they are often larger and may have spores in a thread-like capillitium (page 1646).

Further reading: 302, 316, 326, 355.



Micro-drawings: spores and ascus tops (a).

Approximate species number applies to temperate Europe.

Calicium form very small, stipitate fruitbodies with a widened head, the top of which is powdery from a thick, dark spore mass. Thalli are either superficial or partly immersed in the substrate. Asci dissolve quickly; spores 2-celled, thick-walled and usually ornamented. Lichenized with green algae belonging to the genus *Trebouxia*. Typically on sun-exposed bark and wood.

Calicium viride is a calicioid with a finely grainy, yellow-green thallus. The fruitbodies have rather long, black stems and a convex, black spore mass on the top. The lower side of the head may be ± brown and finely powdery. Asci clavate. Spores dark brown, 2-celled, have a ± regular to irregularly spiralling pattern, and measure 12–14 × 6–7 µm. The algal partner (photobiont) is a *Trebouxia*. Occurs mostly on dry bark and wood, both deciduous and coniferous; mostly in a sterile version. It is rather pollution tolerant.

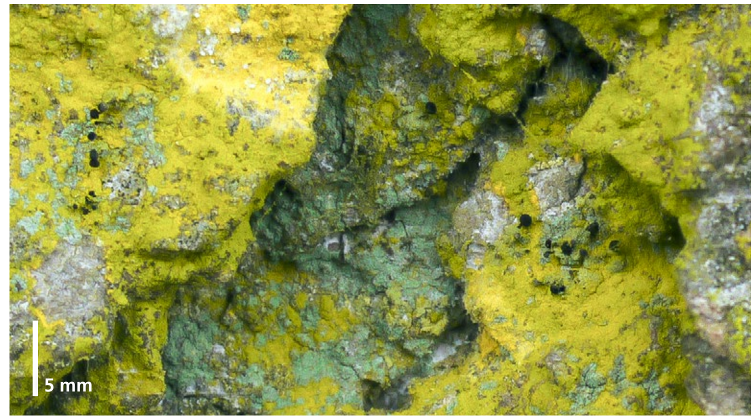
Calicium salicinum ▽ usually has an immersed thallus, browner fruitbodies, cylindrical asci and smaller spores; *C. glaucellum* ▷▷ has small, dark and very open fruitbodies

Widespread, common to occasional; all year.

Calicium salicinum is a calicioid with an almost invisible, ± immersed thallus, fruitbodies with a brown, almost globose head topped with a black spore mass, and stems that are black towards the base. Asci cylindrical. The spores are 2-celled, black, have a spiralling or irregularly cracking pattern and measure 8–11 × 3.5–4.5 µm. The photobiont is a *Trebouxia*. Occurs on dry bark and wood.

Calicium viride △ has a superficial, yellow-green thallus, clavate asci, larger spores and less brown powder on the outside of the head.

Widespread, common to occasional; all year.



Mildews and cleistothecial fungi

Two form groups of ascomycotes with spherical fruitbodies are included here: the mildews (*Erysiphales*), which crack open at maturity and disperse spores actively; and the cleistothecial fungi, which do not open at maturity but decay and disperse the spores passively. In both groups the fruitbodies are very small and may act as dispersal units. To this end, many have a surface with branched or hooked appendages that may attach to passing animals, *etc*.

The mildews are biotrophic plant parasites that form whitish coverings of mycelia on stems, leaves and twigs, from which haustoria can penetrate the living plant tissues (see page 16). The mealy hyphal covering also produces asexual, wind-disseminated conidia. As leaves get older (typically in the autumn), mildews often switch to producing tiny fruitbodies (chasmothecia) that overwinter and crack open when new leaves are available for infection.

The cleistothecial fungi are decomposers of organic material. The genera *Aphanoascus*, *Arthroderma*, *Gymnoascus* and *Onygena* (*Eurotiomycetidae*) are specialists in degrading keratin (hair, horn, *etc*.). Many have prominent asexual states, but they may also produce tiny spherical fruitbodies (cleistothecia, see page 30) with ± globose asci; the spores are released passively as the ascus walls and fruitbodies dissolve/decay.

Other similar fungi:

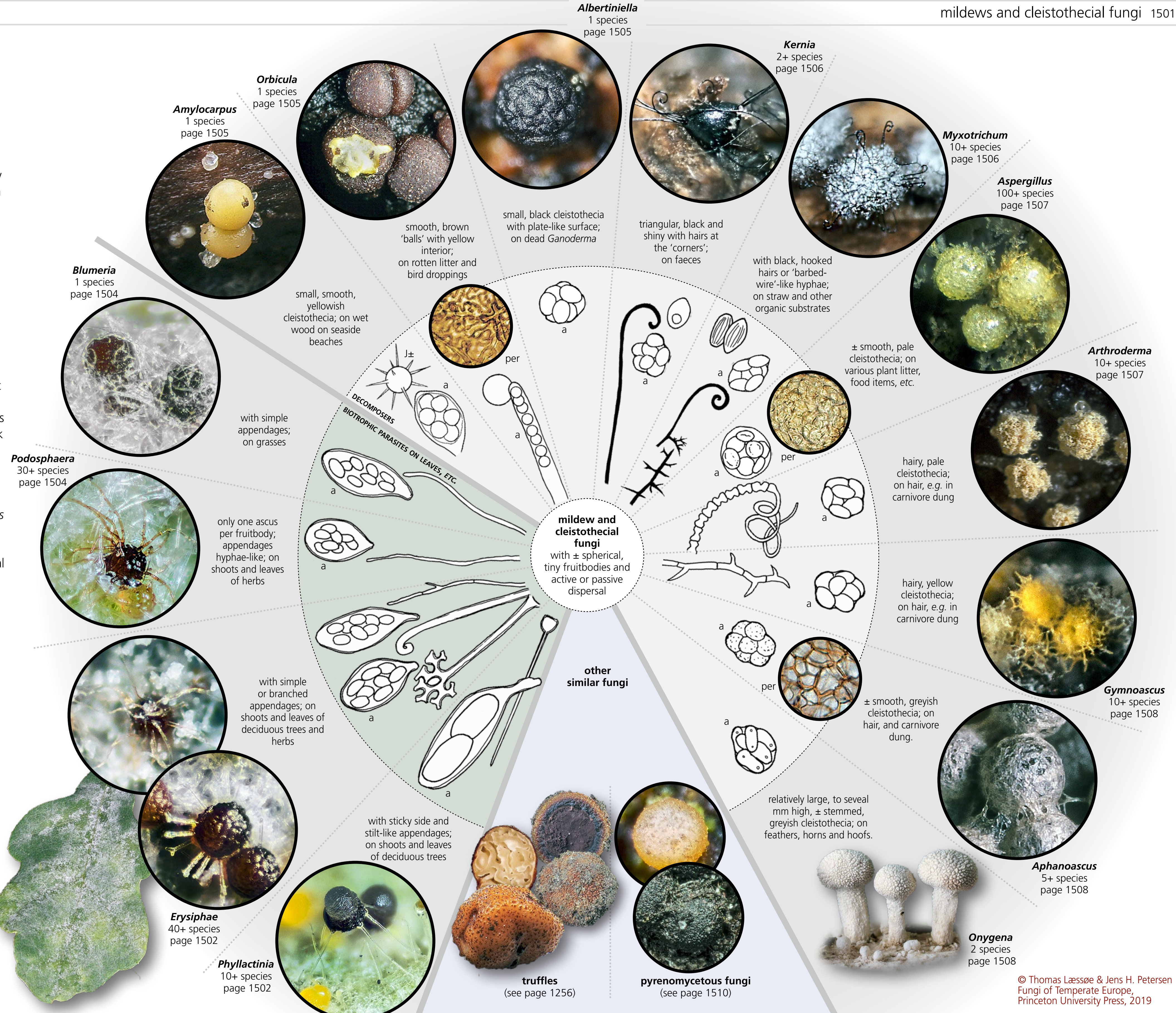
– pyrenomycetous fungi may have an almost invisible opening (ostiole), see page 1510.

– truffles are ± spherical and decay at maturity but are much larger, see page 1256.

Further reading: 35, 47, 68, 72, 73, 78, 79, 80, 164, 188.

Micro-drawings: outermost asci (a) and sometimes spores followed by peridial appendages. Three inset images depict peridia, as seen in a compound microscope (per).

Approximate species number applies to temperate Europe.



Pyrenomycetous fungi

This is a form group of fungi with small, mostly spherical, flask-shaped or sac-like fruitbodies with an opening (ostiole) from where the spores, in most cases, are shot out. The fruitbodies are here all termed 'perithecia' (see more on page 30), although a more precise terminology is often used by mycologists that reflects ontogeny and phylogeny, whereby the fruitbodies of ascomycotes with double-walled asci (right-hand side of the wheel) may be termed pseudothecia, thyriothecia and hysterothecia.

In some species the perithecia are ± imbedded in a uniting flesh, a stroma (pl. stromata), which may be flattened (applanate), cushion-shaped (pulvinate) or club-shaped (clavate).

Many species are decomposers, decaying dead wood, herbs, dung, *etc*, while others are parasites on plants, mosses, insects, *etc*. Some kill insects and spiders and some are lichenized. Many live inside living plant tissues (endophytic) and only fruit when the plant dies.

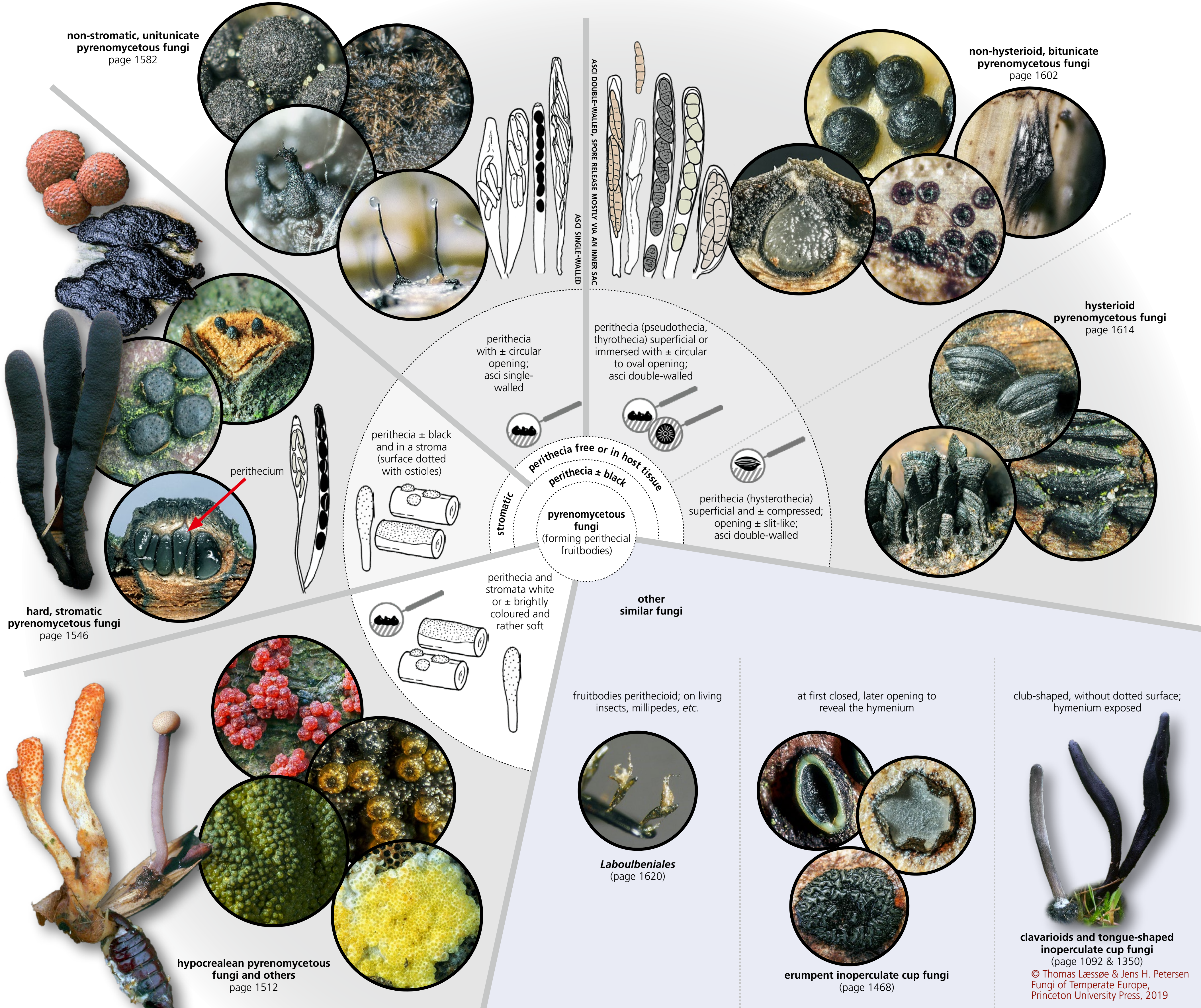
The pyrenomycetous fungi is a very large group with more than 2,500 species in temperate Europe. Parallel evolution has led to similar-looking structures in many ascomycote orders and only very pyrenomycetous fungi can be identified without microscopy. Experience and specialized literature are required for detailed studies of pyrenomycetous fungi, and there are also good internet fora available (for references, see the following wheels).

Other similar fungi:

– *Laboulbeniomycetes* has very small, peritecioid fruitbodies on living insects, millipedes, *etc*. (page 1620).

– some erumpent inoperculate cup fungi may be completely closed, but the hymenium is revealed in wet weather (page 1468).

– fungi with clavate, non-composite fruitbodies may look similar, but the hymenium is on the outside, completely exposed (pages 1092 & 1350).



Hypocrealean pyrenomycetous fungi and others

A form group of fungi with small, mostly globose to flask-shaped perithecia (page 30). The perithecia are typically relatively soft (leathery) and often brightly coloured or whitish; they may be free, sit on a soft, often brightly coloured stroma or immersed in a stroma (page 30). The dots on the surface of the stromata represent the ostioles (perithecial openings). The spores are typically hyaline, or nearly so, and vary from multicelled, thread-like (some split into part-spores) to one-celled; 2-celled spores are common and may split into two at maturity.

Many species are parasitic on plants, animals or fungi. Species of *Hypomyces* may replace parts of the living fruitbodies of larger fungi with perithecia. *Cordyceps* and *Ophiocordyceps* are predatory fungi that kill insects and spiders, later producing stromata from the carcasses. *Epichloë* and *Claviceps* live as endophytes in grasses and other monocots; they are well known due to their toxic alkaloids (ergotism is caused by *Claviceps*).

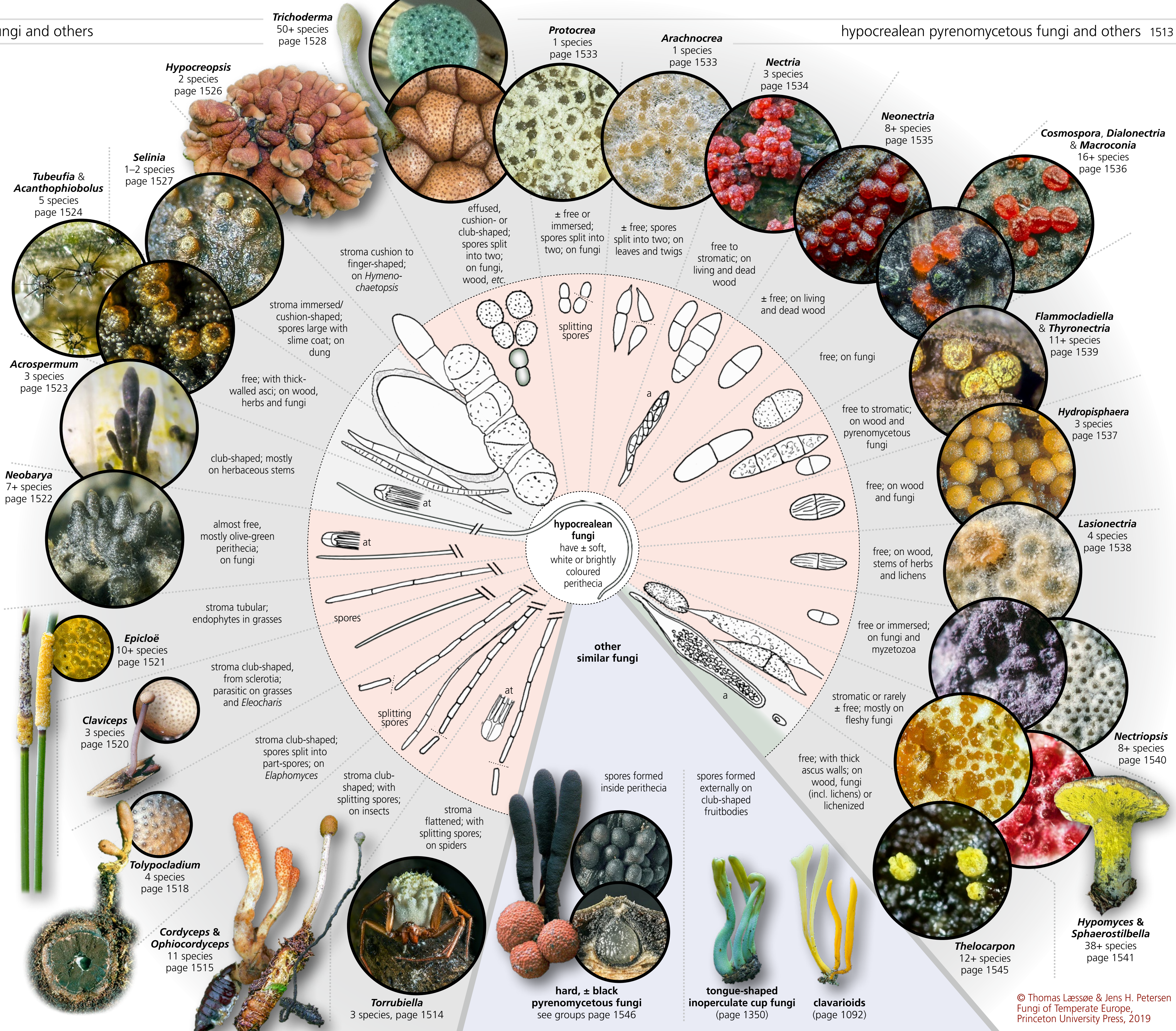
OTHER SIMILAR FUNGI:
– hard, ± black pyrenomycetous fungi are more carbonous (page 1546).
– clavarioid basidiomycotes and tongue-shaped inoperculate cup fungi, have external hymenia, and thus no dots from immersed perithecia (pages 1092 & 1350).

See also the general wheel, page 1510.

FURTHER READING: 48, 55, 60, 96, 106, 107, 128, 129, 131, 132, 175, 248, 274, 275, 278, 279, 280, 284, 302, 311.

Micro-drawings: spores first, followed on the inside by asci (a) and ascus tops (at).

Approximate species number applies to temperate Europe.



Hard, stromatic pyrenomycetous fungi

A form group of fungi with black, mostly rather carbonized perithecia that are ± immersed in a stroma (plural stromata), and which may be club-, nail- or cushion-shaped or quite flat. The stroma may be well defined, as in most genera on the left hand side of the wheel, or composed of a mixture of tissue from the host plant and the fungus, as in many species on the right hand side of the wheel.

All species are decomposers, but some may also kill the host, *e.g. Kretzschmaria deusta* and *Eutypa spinosa*. Some species may survive as endophytes in living tissues and only become active when the host dies.

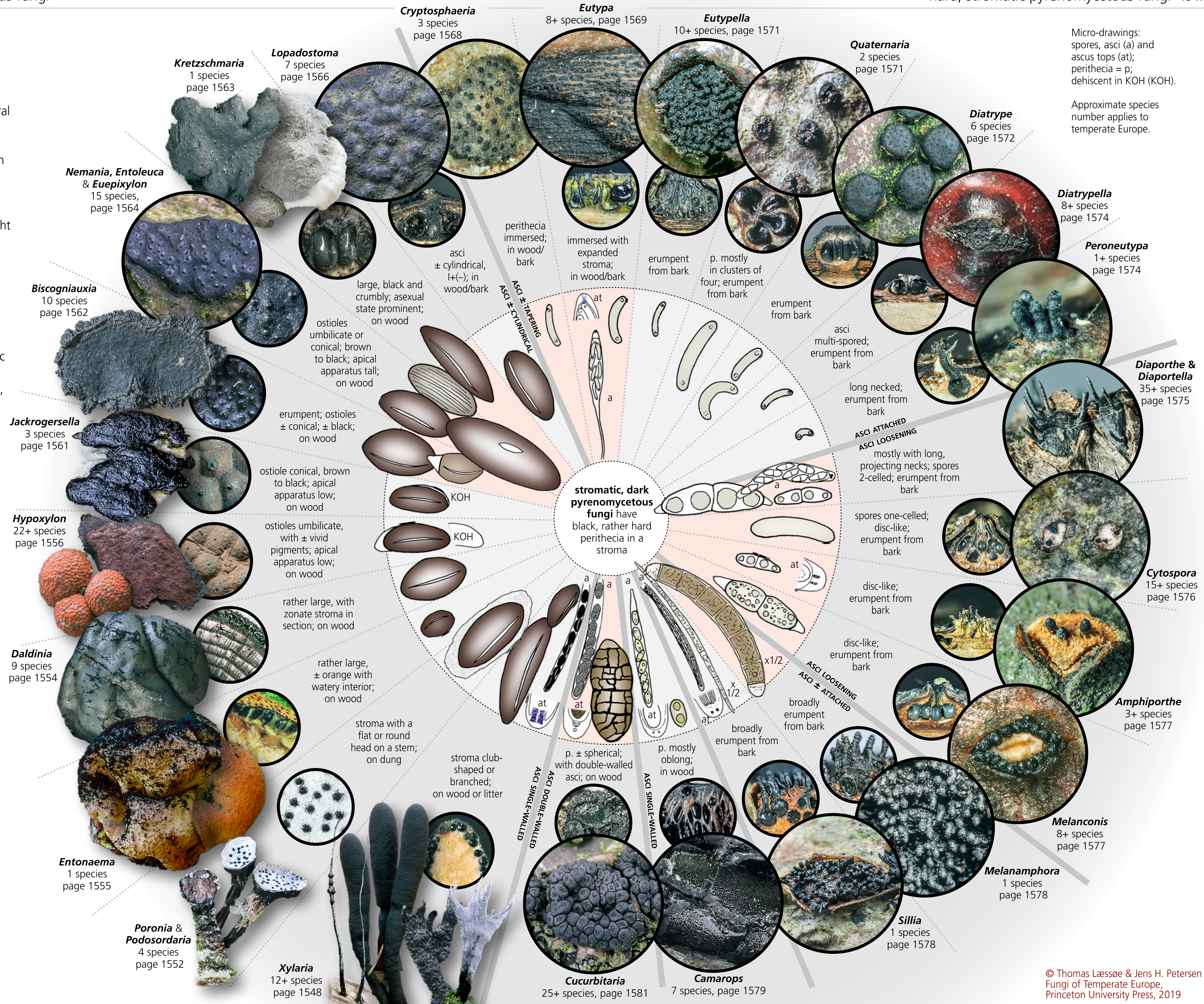
The majority of the hard, stromatic pyrenomycetous fungi are found in three families: *Xylariaceae* has brown, ± asymmetrical ellipsoid spores, mostly with a germ slit; *Diatrypaceae* has paler allantoid spores and asci with a long tail-like base; and *Diaporthaceae* has hyaline, 1–2-celled spores and loosening asci. The first two families mostly have an amyloid ascus apparatus.

The genera *Daldinia, Hypoxylon*, and *Jackrogersella* have diagnostic pigments that can be dissolved with KOH; scrape the surface onto blotting paper and add a drop of 10% KOH (corrosive) – the pigment will be drawn into the paper (see pages 1557–1560).

Other similar fungi:
– hypocrealean pyrenomycetous fungi have a softer texture and paler or brighter colours (page 1512).
– the non-stromatic pyrenomycetous fungi and the bitunicate pyrenomycetous fungi have ± free perithecia (pages 1582 & 1602).

See also the general wheel, page 1510.

Further reading: 61, 78, 82, 83, 93, 130, 179, 250, 251, 254, 255, 256, 313, 314, 353.



Non-stromatic, unitunicate, dark pyrenomycetous fungi

Species in this form group have more or less solitary, perithecia and the asci have single walls (unitunicate). They are generally ± brown or black but may be covered in white or more colourful hairs. The perithecia may be seated on the surface of the substrate or immersed and almost invisible, with only the ostiolar necks appearing at or above substrate level.

The majority of the species are decomposers of leaves, herbaceous stems, wood or dung – a few are parasitic.

The non-stromatic pyrenomycetous fungi form a heterogeneous group of fungi with representatives from a range of orders, of which *Sordariales* is the most prominent. Many of these species produce large, ± brown spores.

Other similar fungi:

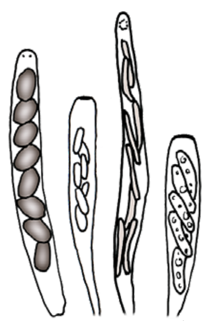
– the bitunicate pyrenomycetous fungi have thick, double-walled asci. The spores are mainly released when the outer wall ruptures, allowing an inner sac to stretch out (page 1602).

– hypocrealean pyrenomycetous fungi can also be non-stromatic, but the perithecia are mostly brightly coloured and rather soft (page 1512).

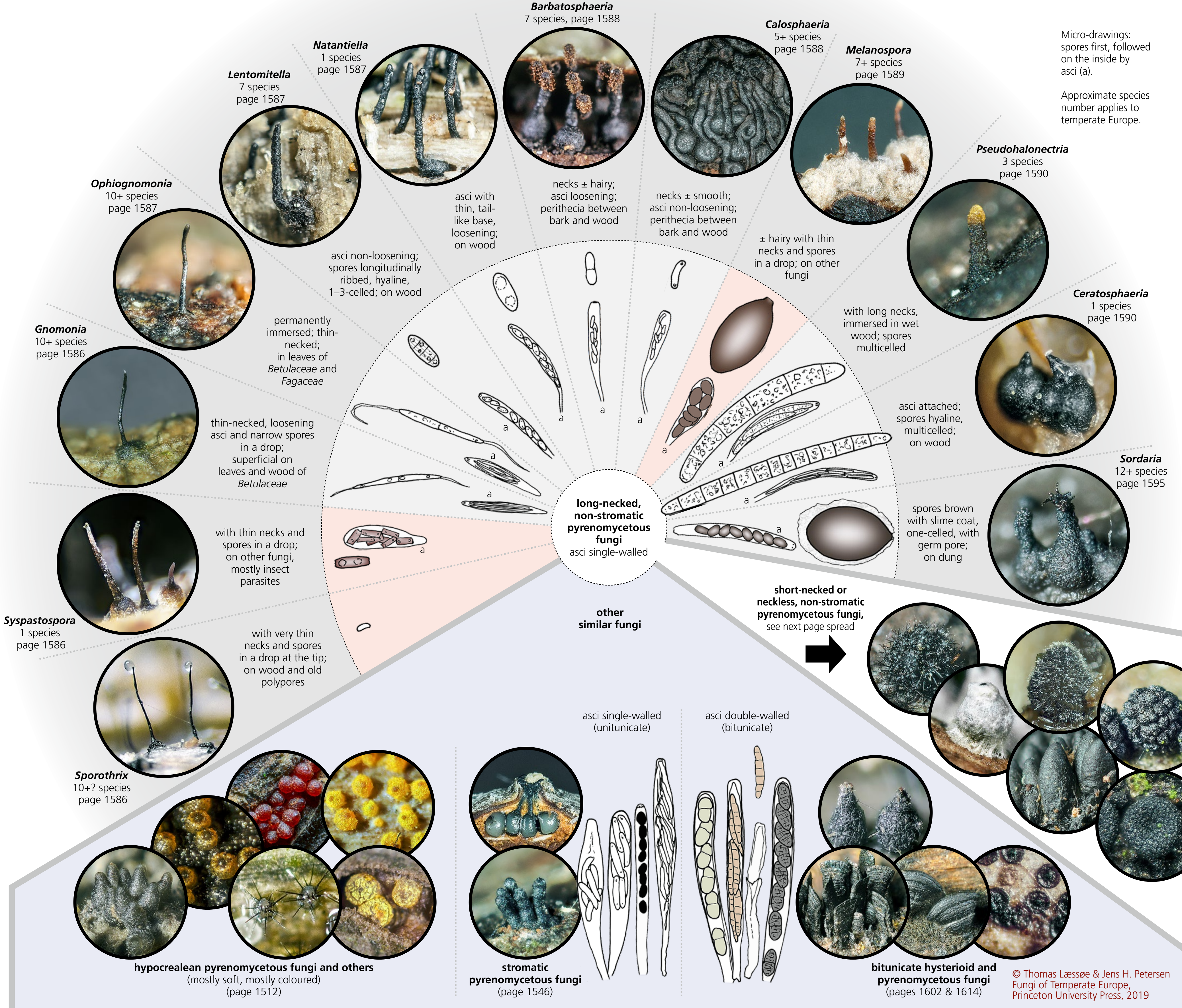
– the dark stromatic pyrenomycetous fungi grade into the non-stromatic. For species with immersed perithecia it can be especially difficult to determine whether or not a stroma is present (page 1546).

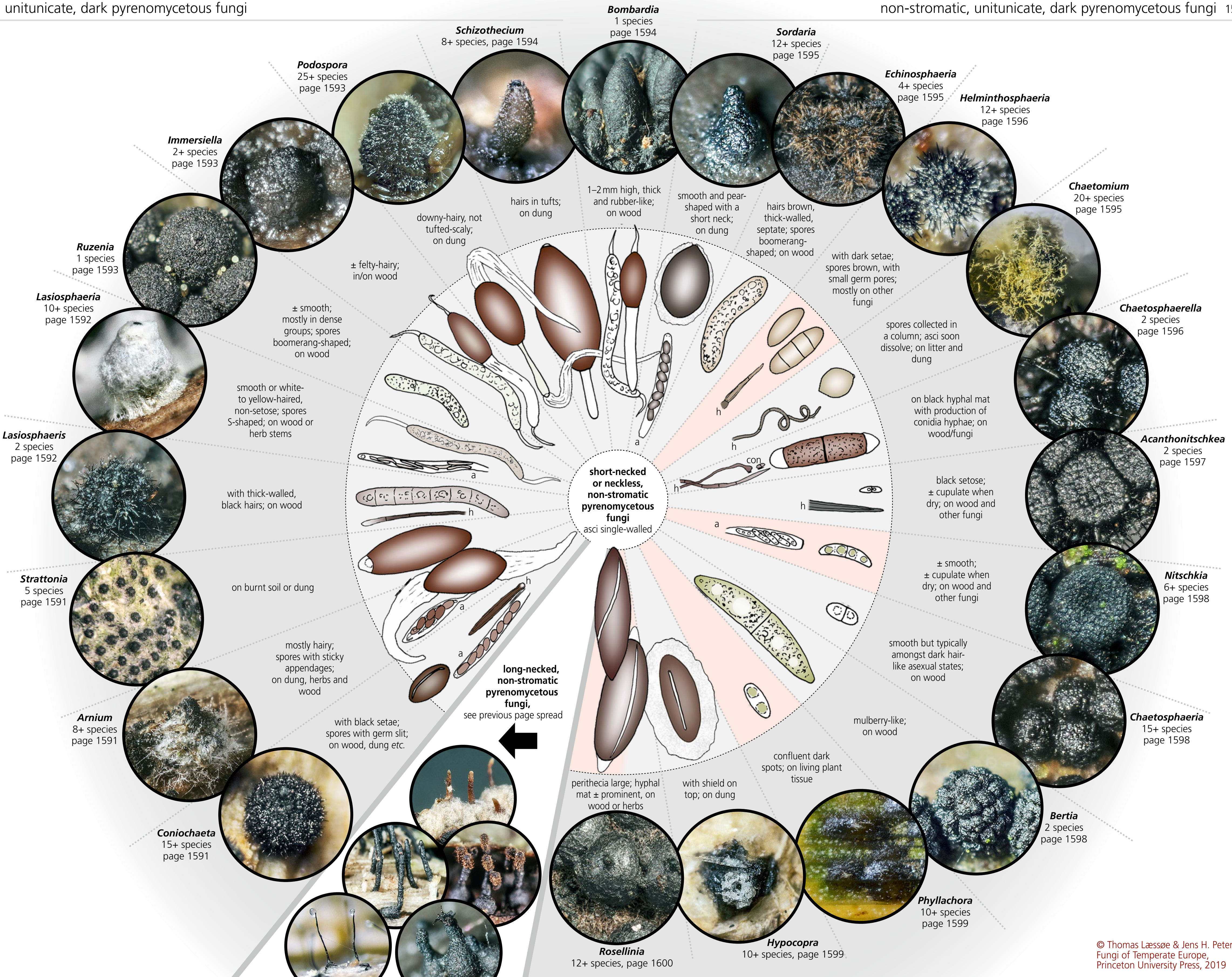
See also the general wheel, page 1510.

Further reading: 16, 54, 58, 62, 73, 78, 185, 195, 196, 247, 257, 258, 259, 260, 261, 304, 350, 353.



Asci with single walls (unitunicate).





Micro-drawings: spores first, followed on the inside by asci (a), hairs (h) and conidia (con).

Approximate species number applies to temperate Europe.

Non-hysterioid, bitunicate pyrenomycetous fungi

Species in this form group have thick-walled asci with several functional wall layers. Most species have small, free perithecia (also termed pseudothecia) or even smaller, circular, flattened perithecia (termed thyriothecia – page 1604).

The young asci are typically very thick-walled, especially the upper parts, where a characteristic bulge often can be seen (see arrow below). The spores are ejected from an inner sac that stretches out from the outer sac once the ascus tip ruptures – a so-called jack-in-the-box mechanism.

Most species in this form group are plant parasites, or decomposers of wood, herbs or dung.

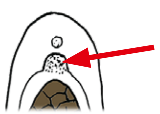
Other similar fungi:

– the ± black, non-stromatic unitunicate pyrenomycetous fungi are similar but the asci are single-walled (page 1582).

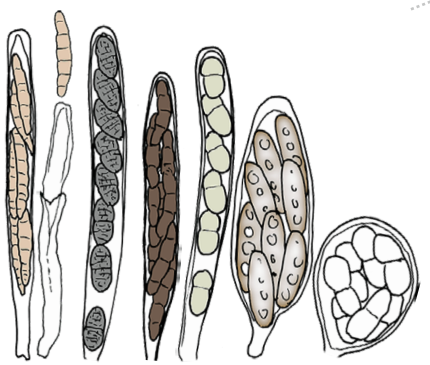
– the hysterioid pyrenomycetous fungi have similar asci (and phylogenetically belong to the same class), but have compressed, superficial fruitbodies that open by a narrow slit (page 1614).

See the wheel page 1510.

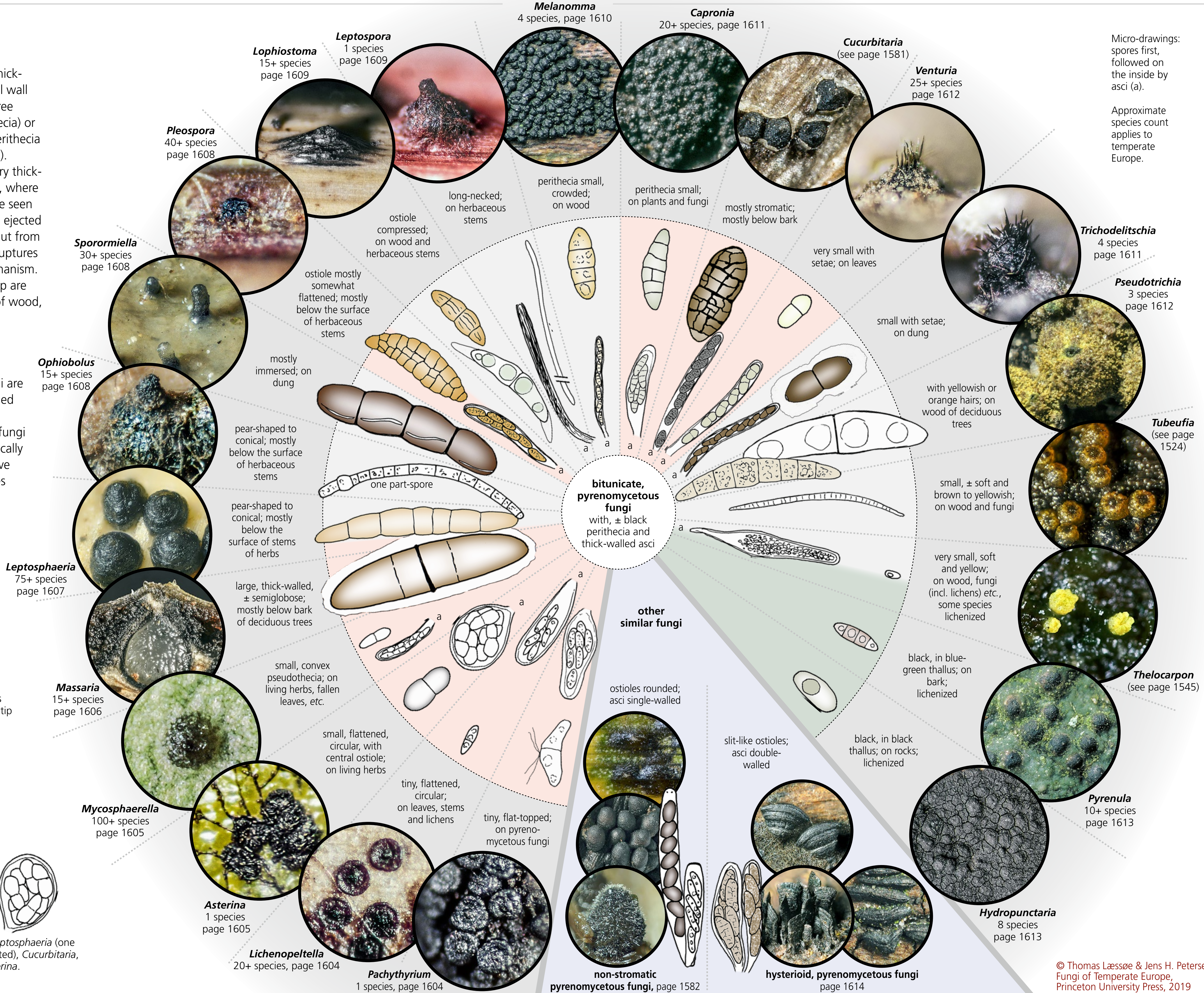
Further reading: 61, 73, 77, 78, 84, 234, 299, 300, 302, 312, 347, 353, 357.



Asci in most bitunicate pyrenomycetous fungi have a characteristic thick-walled tip with a bulge, here in *Cucurbitaria*.



Asci with bitunicate walls – from left *Leptosphaeria* (one mature and one with the inner sac ejected), *Cucurbitaria*, *Sporormiella*, *Venturia*, *Massaria* & *Asterina*.



Micro-drawings: spores first, followed on the inside by asci (a).

Approximate species count applies to temperate Europe.

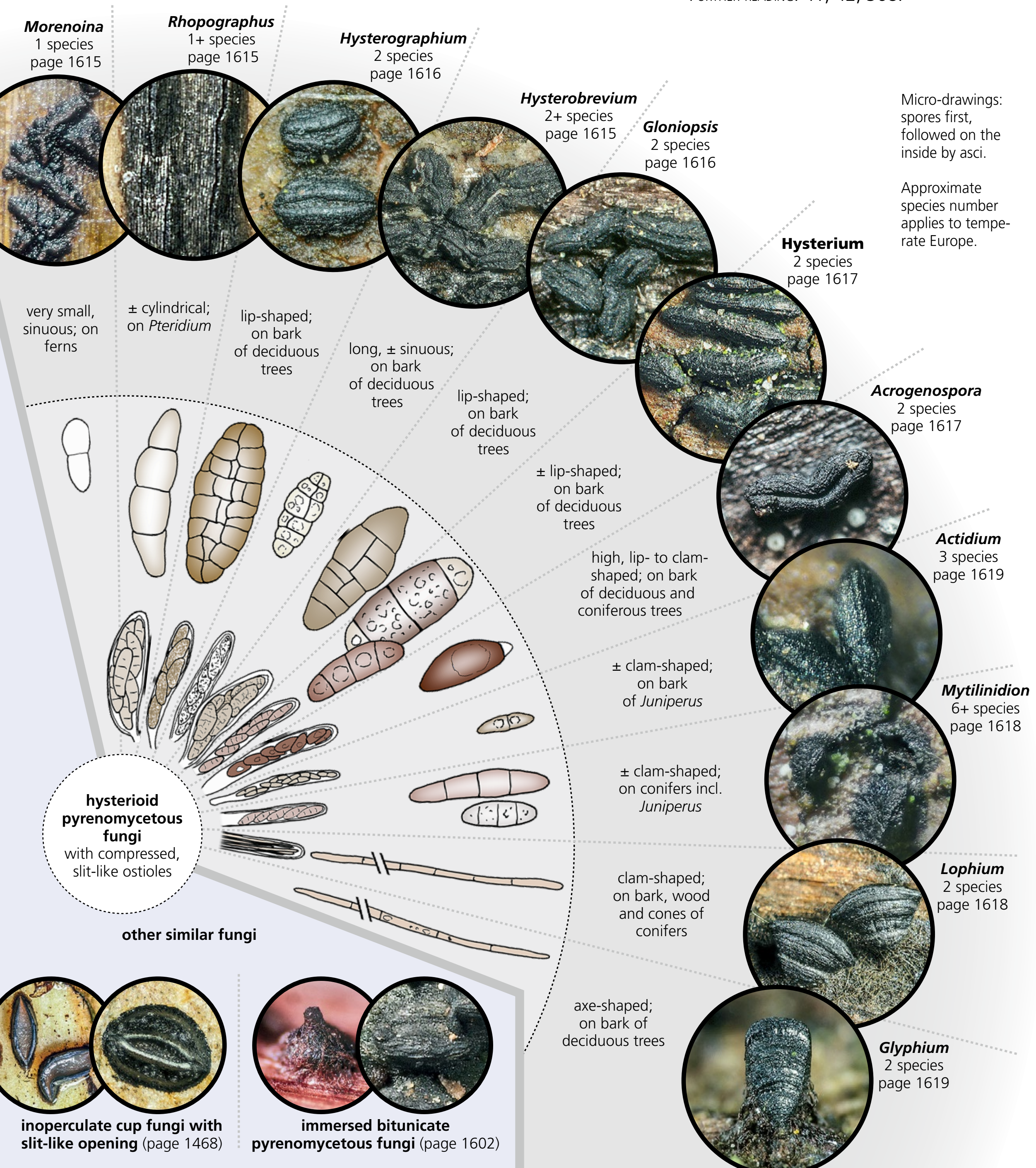
Hysterioid pyrenomycetous fungi

This group of fungi includes species with mostly superficial perithecia that have distinct, ± compressed ostioles and a slit-like opening (hysterothecia). The fruitbody shape is highly variable: many are elongate, others clam- or axe-like. All have double-walled asci (bitunicate) that typically release the spores after an inner sac has stretched through the outer sac (jack-in-the box-release).

All species are decomposers of wood, cones, herbs, *etc.* They mostly occur in exposed, dry habitats, *e.g.* on bark of ± sun-exposed twigs.

Other similar fungi:
– inoperculate cup fungi with slit-like openings reveal the hymenium in wet weather. They have single-walled (unitunicate) asci (page 1468).
– some bitunicate pyrenomycetous fungi (*e.g. Lophiostoma*) have flattened ostioles, but the fruitbodies are immersed in the substrate (page 1602).

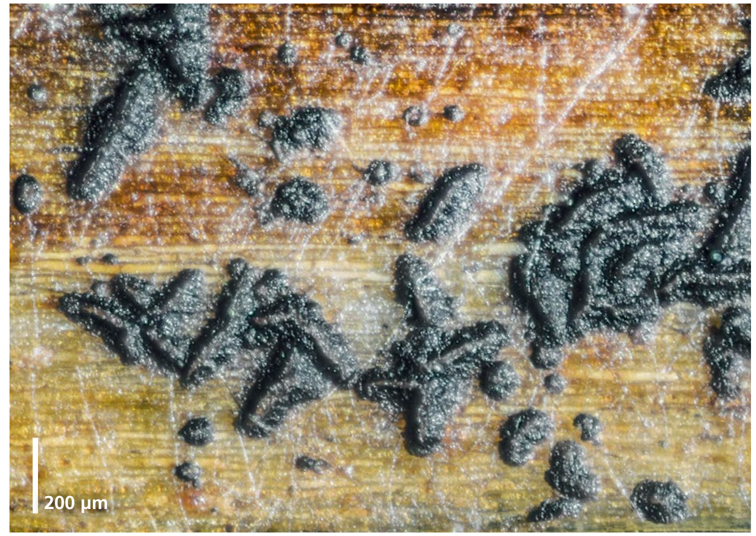
Further reading: 41, 42, 368.



Morenoina pteridicola is a black, bitunicate pyrenomycetous fungus with oblong, somewhat branched, very small, ± flattened fruitbodies that have slit-like ostioles. The margin has brown, radiating, ± branching hyphae. Asci double-walled, measure 18–27 × 9–14 µm. The spores are 2-celled, not completely symmetrical, smooth, somewhat brownish when old, measure 9–13 × 3–4 µm. Occurs on petioles of *Dryopteris*, *Pteridium* and probably other ferns.

There are apparently no other similar species on these substrates.

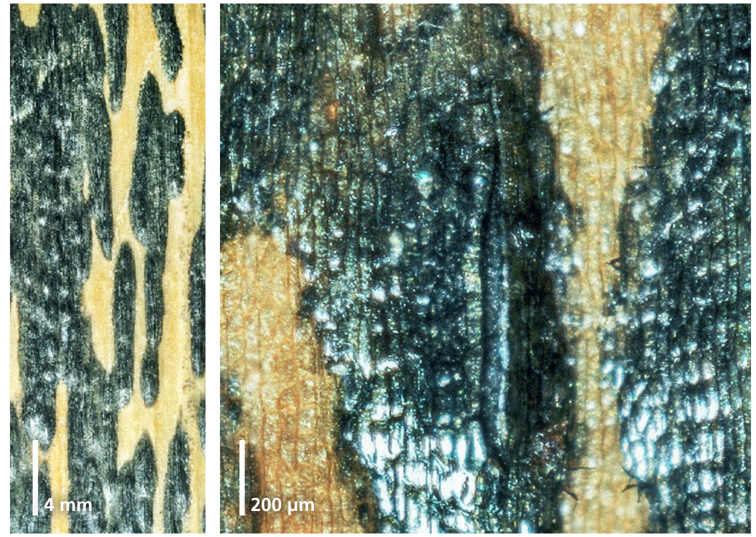
Possibly widespread, but very rarely reported, most likely overlooked; most of the year.



Rhopographus filicinus is a bitunicate pyrenomycetous fungus that forms elongated-oblong, black, ± confluent fruitbodies with slit-like ostioles along the length of the hosts' 'stems'. Asci double-walled, 8-spored, measure 70–86 × 20–25 µm, I-. The somewhat bent, yellow-brown, 4–8-celled spores measure 27–35 × 7–8 µm. Occurs on petioles of *Pteridium*.

Scirrhia aspidiorum ⨯ forms grey fruitbodies/stromata and hyaline 2-celled spores.

Widespread, very common; all year.



Hysterographium fraxini has elongated, black, longitudinally furrowed, half-open fruitbodies (hysterothecia) that may branch slightly. Asci double-walled, I-. Spores yellow-brown, muriform-septate with a slightly constricted middle septum and many transverse and longitudinal septa; they measure 40–48 × 16–20 µm, are mostly broadly rounded and have a slime coat. Mainly occurs on *Fraxinus* bark.

Hysterographium flexuosum ⨯ has somewhat longer, more pointed spores; *H. elongatum* ⨯ apparently has 1 or no longitudinal septa, but is perhaps just a synonym of *H. fraxini*.

Widespread, occasional; all year.

Laboulbeniales

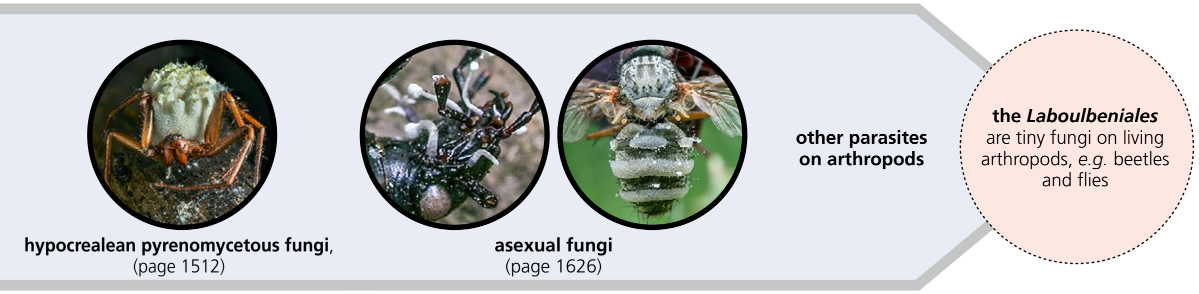
The *Laboulbeniales* are tiny, 0.03–2 mm high, ascomycotes that grow on living insects, millipedes and other arthropods. Each species has one or several hosts and some are always situated on specific areas of the host, *e.g.* the antenna. The entire fungus (thallus) includes a dark 'foot', a stem, a perithecium (with asci and 2-celled spores with a slime coat), antheridia, which form spermatia, and finally sterile appendages. During the sexual process spermatia are transferred from the antheridia to a trichogyne. After this the perithecium develops.

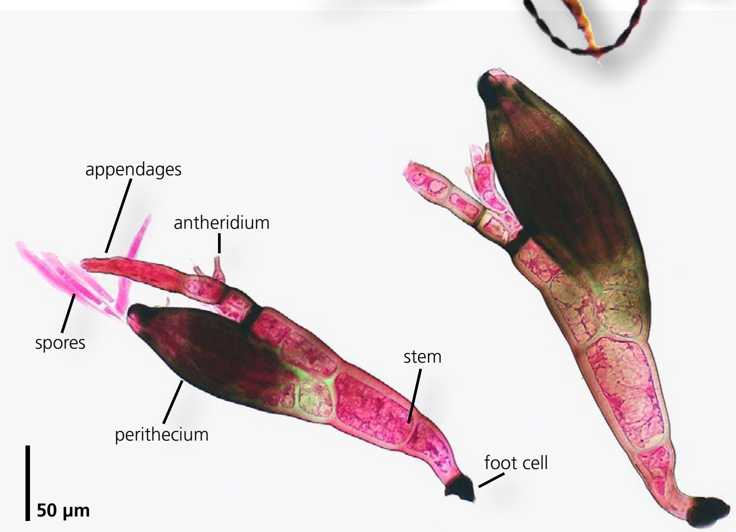
The *Laboulbeniales* do not have a true mycelium, and apparently do not enter the host cavity, but get their nutrients only from the exoskeleton. Large aggregations of fruitbodies may weaken some hosts.

The *Laboulbeniales* belong in their own class, *Laboulbeniomycetes*, with 50+ genera in temperate Europe. Only a few examples are included here – all from beetles.

Other similar fungi:
– insect parasites are also found among the hypocrealean fungi (page 1512), and within the asexual fungi (pages 1630, 1635 & 1643), but none resemble *Laboulbeniales*.

Further reading: 114, 117, 187, 352.





Jimmie Høier

Laboulbenia is the largest genus of the *Laboulbeniales*. It has a short foot cell and lateral appendages.

Laboulbenia argutoris is an approximately 275 µm long *Laboulbenia* with a dark olive-brown, perithecium about 125 µm long. The outer, simple appendages may have up to 9 cells. Spores asymmetrically 2-celled, hyaline, and have a thick slime coat that enables it to stick to the host animal. Occurs on beetles in the genus *Pterostichus*.

At least four species of *Laboulbenia* occur on this type of beetle. *Laboulbenia pseudomasei* ⋉ and *L. flagellata* ▷ have more complex outer appendages than those in *L. argutoris*. *Laboulbenia kajanensis* ⋉ is very similar to *L. argutoris* but has small differences in cell dimensions.

Distribution and frequency not well known, but probably rather common; all year.

Laboulbenia flagellata is a ± olive-green *Laboulbenia* with a thallus about 400 µm long. The perithecia appear from three large basal cells that arise from the dark attachment cell. The appendages appear from a 2-celled extension of the basal cells. Occurs on a number of carabid beetle genera and species.

A very variable and rather difficult species to identify, with identification further complicated by the long list of hosts.

Probably widespread and common; all year.

Jimmie Høier

Monoicomyces fragilis is a laboulbenialean fungus with thalli approximately 200 µm long and 140 µm wide. Each thallus divides above cell two, and one perithecium develops on each side. Two long appendages with brown basal pigmentation arise from just above the lower pigmented cell. Spores hyaline, 2-celled, and have a slime coat. Occurs on the rove beetles *Ocalea picata* and *Oxypoda opaca*.

The distinctive split thallus makes this species easy to identify.

Distribution and frequency poorly known; all year.

Jimmie Høier

Rhachomyces furcatus is a complex laboulbenialean fungus, up to 500 µm long with many dark appendages and one or two, ± centrally positioned, approximately 250 µm long perithecia. The cell size gradually increases up to the cell that supports the perithecium, and decreases again above it. The spores are 2-celled, hyaline, and have a slime coat. Occurs on rove beetles in the genus *Othius*.

A relatively easy species to recognize, provided the host animal is taken into account.

Distribution and frequency poorly known; all year.

Jimmie Høier

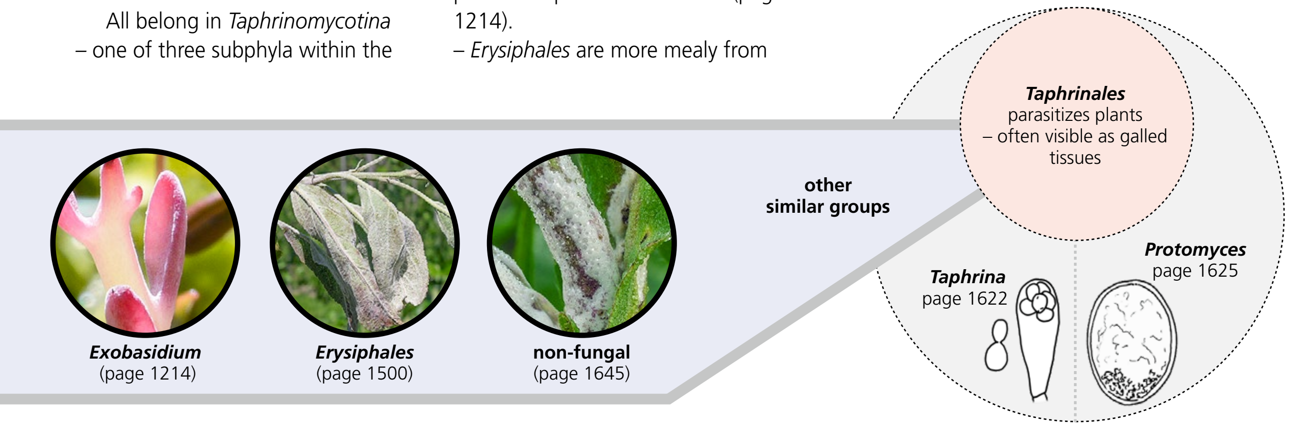
Taphrinales

Species in the order *Taphrinales* are all biotrophic plant parasites that never form proper fruitbodies, but mostly produce a layer of asci within the host tissue. The hosts may be galled in various ways, from small leaf blisters to huge witch's brooms in the crown of infected trees.

All belong in *Taphrinomycotina* – one of three subphyla within the phylum *Ascomycota*. The other two subphyla are the yeasts in *Saccharomycotina* and the often fruitbody-forming *Pezizomycotina* (page 12).

OTHER SIMILAR FUNGI:
– the basidiomycotes in *Exobasidium* parasitize species of *Ericaceae* (page 1214).
– *Erysiphales* are more mealy from surface production of conidia and form small spherical fruitbodies with asci (page 1500).
– some non-fungal organisms, *Albugo* for example, may look similar but do not have basidia or asci (page 1645).

FURTHER READING: 78, 80, 87, 164.



Taphrina is a large genus of plant parasites. All species deform the infected tissue in more or less spectacular ways: from curly or blistered leaves, through deforming fruits, to inducing 'witch's brooms'. The small asci are formed in a palisade directly on the surface of the host tissue. The spores mostly produce yeast stages within the asci. When sporulating the infected tissue may have a pruinose appearance.

Taphrina betulina causes the formation of Magpie nest-like witch's brooms. The asci are formed in the leaves of the host, which appear from the brooms; they measure 25–70 × 10–25 µm and are I-. Spores measure 4–6.5 × 2.5–5 µm. Occurs in the crown of living *Betula* trees.

Other organisms may also cause the formation of witch's brooms in *Betula*, so in reality reliable identification requires microscopy. *Taphrina betulae* ⋉ forms discoloured, swollen spots on the leaves of *Betula* rather than conspicuous galls.

Widespread, very common; all year (as brooms).

Taphrina wiesneri causes a very spectacular formation of drooping witch's brooms. The asci are formed on discoloured, somewhat bumpy leaves; they measure 17–35 × 15 µm and are I-. The spores measure 3.5–9 × 3–6 µm and form yeast-like cells. Occurs on both cultivated and wild species of cherry (*Prunus cerasus* and *P. avium*).

In order to ensure a correct identification, infected leaves require microscopical investigation.

Mainly nemoral–hemiboreal, rather common; all year (as brooms).

Taphrina carpini forms conspicuous witch's brooms. Asci occur on the pale leaves of the host that appear as long shoots from the brooms; they measure 20–30 × 7–15 µm. The spores measure 3.5–5 × 3–4.5 µm. Found on *Carpinus*, including in mature hedgerows.

Microscopical investigation is recommended as other organisms can induce the formation of witch's brooms in *Carpinus*.

Nemoral, rather common; all year (brooms).

Tom Smidth

Taphrina farlowii deforms leaves, shoots and fruits of the host with yellowish to reddish blisters and swollen galls. The asci are formed on the galls and measure 20–30 × 8–9 µm, the basal cell measures 8–9 × 15–25 µm. The spores are ± spherical to broadly egg-shaped and measure 4–6 × 4–5 µm. Affects *Prunus serotina*, a North American species that is widely planted and now spreading.

The very similar *T. deformans* ⋉ deforms the leaves of other *Prunus* species, including *P. amygdalus* and *P. persica*.

Nemoral, probably common; mainly June–October.

Asexual fungi

Many fungi have asexual states where propagules are produced following mitotis rather than meiosis. These mitospores (typically termed conidia) are ± genetically identical to the mycelium that produced them. Contrary to this, meiospores (in this publication termed spores) are formed in, for example, asci, or on basidia, by a sexual process that involves nuclear fusion and subsequent meiosis, see pages 11 & 22.

Many species produce both sexual and asexual states. Where the two states occur together both states are usually included in the description of the sexual state.

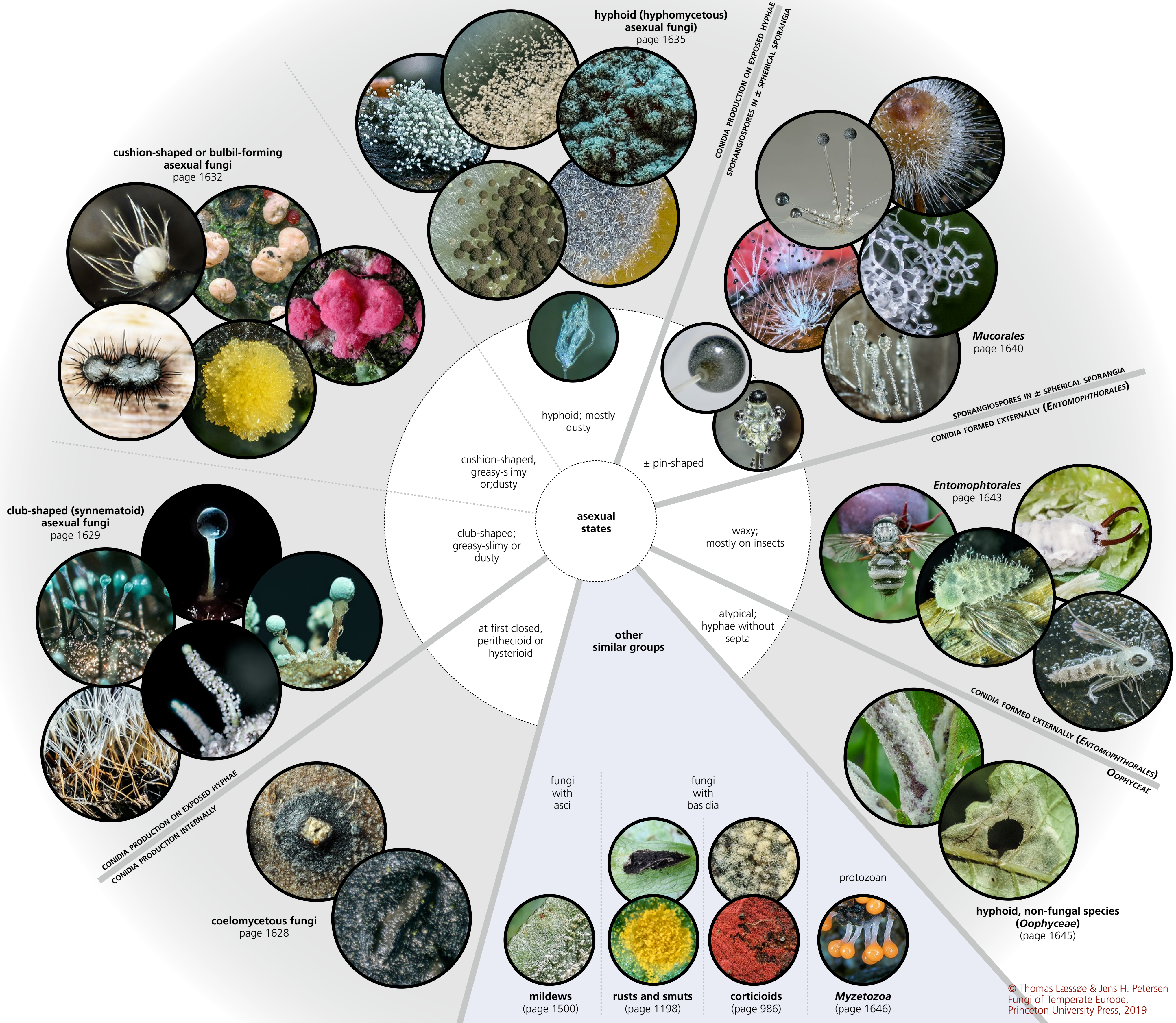
Traditionally, asexual and sexual states were given separate scientific names. For example, *Aspergillus glaucus* (page 1507) was the name for an asexual state, while *Eurotium herbariorum* was the name for the sexual state of the same species. However, in 2011, the code that governs the naming of fungi was changed so that one name is used, the first described taking precedence irrespective of the state to which it was attached. Thus, *Aspergillus glaucus* became the valid name for all states of this fungus.

Asexual fungi constitute a pool of thousands of 'species'. These are not a main theme of this publication, and on the following pages only a few characteristic examples are given.

Asexual propagation is found in almost all fungal groups. However, the more spectacular examples are found mainly within the ascomycotes and zygomycotes, and less so within the basidiomycotes.

Other similar fungi:
– species of mildew form asexual spores from a mealy covering on living leaves, but later form tiny, spherical fruitbodies with internal asci (page 1500).
– rusts and smuts have a series of asexual spore states, see page 1198.
– cobweb-like corticioids may look similar to asexual moulds but form meiospores from basidia (page 986).
– *Myzetozoa* (slime moulds) may look similar to asexual fungal moulds (page 1646).

Further reading: 78, 94, 144, 145, 146, 293, 294, 321, 351, 369.



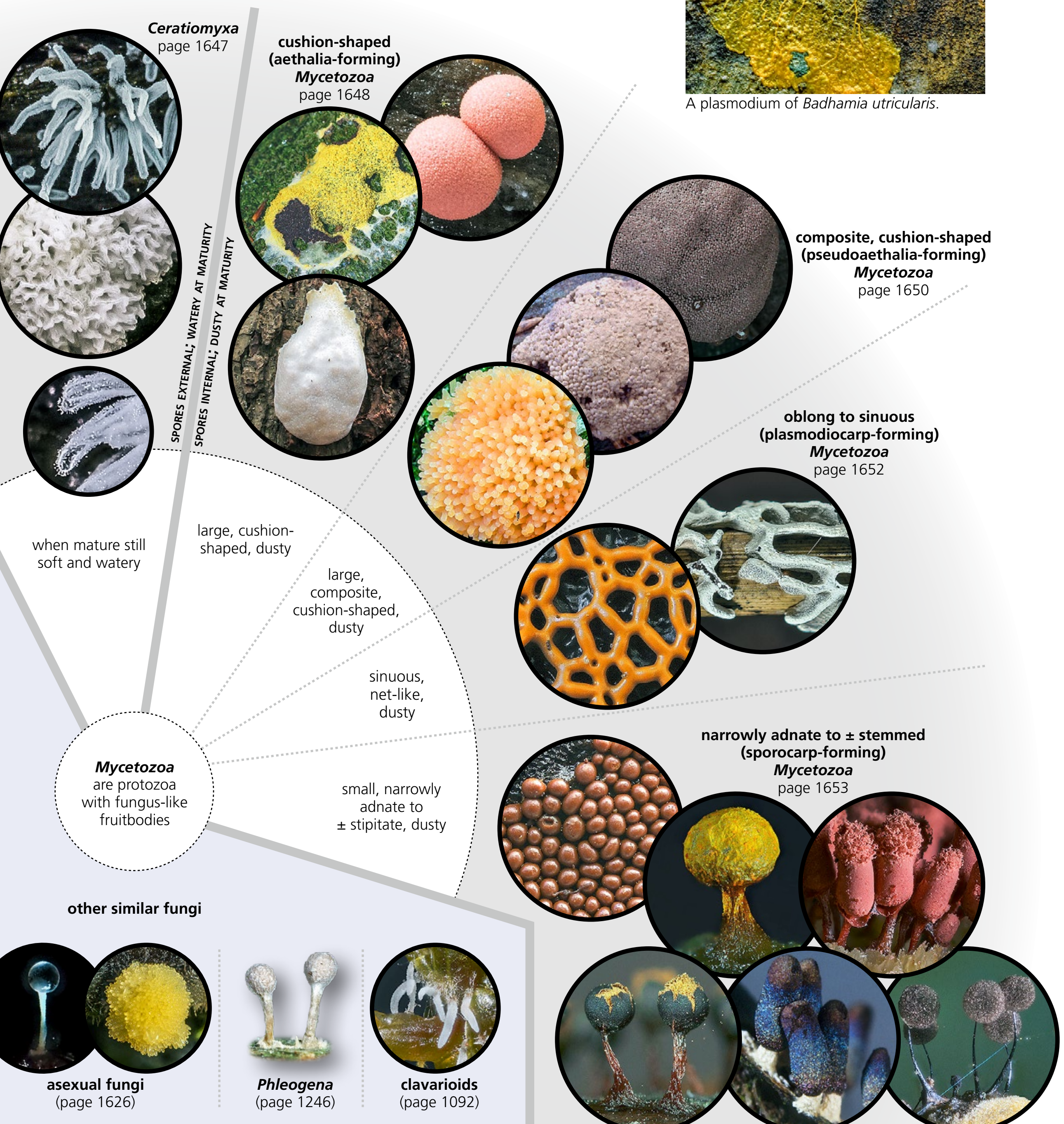
Mycetozoa

Mycetozoa (slime moulds) do not belong in the fungal kingdom but within the *Protozoa*, However, their spore-producing structures may resemble those from fungi. They ingest organic particles in their mobile amoeboid stages and can be found in many environments, particularly on bark and rotten wood. The amoeboid stages range from tiny to huge. The sporulating stage mostly has internal spore production and the spores can be mixed with a hyphoid capillitium. There are approximately 48 genera in temperate Europe; a few examples are included here to show the variation.

Other similar fungi:
– asexual fungi may look similar (page 1626).
– *Phleogena* (page 1246) has dusty fruitbodies but transversely divided basidia.
– small clavarioids have basidia and are not dusty at maturity (page 1092).

Further reading: 120, 217, 249.

A plasmodium of *Badhamia utricularis*.



Ceratiomyxa fruticulosa is a white to somewhat yellowish slime mould with external spore production (inset image). It forms large, dense areas of long-branched fruitbodies that ± dissolve when touched. The egg-shaped to broadly ellipsoid, mostly hyaline, smooth spores are positioned on a small stem and measure 8–15 × 6–10 µm. Occurs on rotten wood, both deciduous and coniferous.

The variety *Ceratiomyxa fruticulosa* var. *porioides* (lower image) almost looks like a resupinate polypore but is much softer and disintegrates when touched. *Mucronella* (page 1096) and *Ceratellopsis* (page 1097) are firmer when touched and have basidia. *Ceratiomyxa* is not closely related to the other groups of slime moulds.

Widespread, very common; May–October, peaking during the summer.

Thomas Læssøe