FUNGI FORAGERS

No. 38: March 2024

OUR PURPOSE: TO RAISE AWARENESS AND INTEREST IN FUNGI OF THE CAIRNS REGION

This newsletter is not associated with any club or organisation but is emailed free of charge to anyone who may be interested. Anyone who wishes to contribute to the newsletter with observations, anecdotes, corrections, comments, or photographs is welcome to do so. Although this "newsletter" is science-based we try not to make it too "scientific". We recognise that there are school children, bush-walkers and others just interested in fungi, and we hope this leaflet will become a medium for furthering that interest. **The emphasis is on fungal biology and ecology** rather than identification.

Barry Muir

Field meetings to find interesting species of fungi (not necessarily edible species) are known as 'forays', after the first such meeting organized by the Woolhope Naturalists' Field Club, Herefordshire, England, in 1868 and entitled "A foray among the funguses" [*sic*]. The Woolhope Club was an early member of the British Mycological Society founded in 1896. (Wikipedia)

DELAYED PUBLICATION

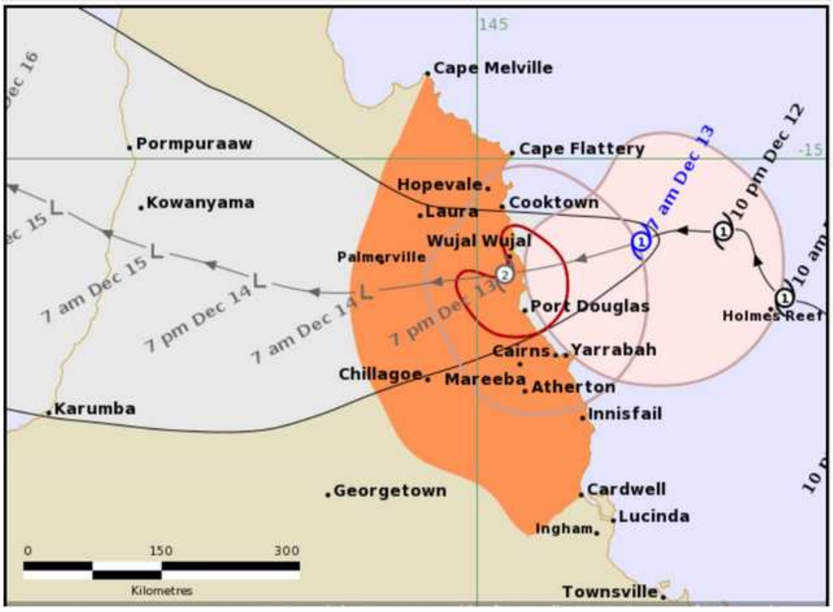
Firstly, my apologies for running late with this edition. Once again, I have seen the inside of Cairns Base Hospital and had my wet season fungal studies put on hold by health issues. My recommendation is that you do not grow old – it's not worth it! 😊

THE 2023 – 2024 WET SEASON – BREAK OF RAINS

In Cairns Fungi Foragers (CFF) No 35 Supplement 4 and CFF 36 Supplement 5, there were detailed discussions of the importance to fungi of the first substantial rains at the commencement of the summer wet season, locally known as "break of rains" (BOR).

The first substantial BOR falls in seven of the last eight years occurred in mid- to late December and this 2023/2024 wet season was the same. Tropical Cyclone Jasper began dumping rain on north Queensland on 13 December and continued almost without break for five days, with a ferocity not seen for decades. Official rainfall at the Cairns Airport over those five days is unknown because the Bureau of Meteorology's weather station failed, but, at my place in Whitfield 4 km south-west of the Airport was 838 mm, and at my friend Ray's place in Redlynch 7 km south-west of the Airport was 1247 mm. These are not excessive amounts, but the intensity and short duration overwhelmed catchments leading to major flooding.

Many areas, especially Port Douglas and Wujal Wujal, north of Cairns, and the Barron River Catchment, were severely flooded, with hundreds of homes damaged and millions of dollars of damage to bridges, roads, and other infrastructure. Hundreds of families lost almost everything they owned, and it will take months for infrastructure services to be rebuilt.

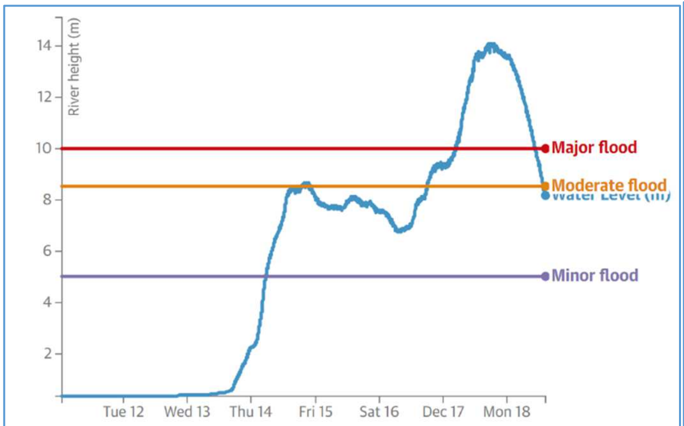


Tropical Cyclone Jasper track with dates, times and locations. It crossed the coast at Category 2.

Observations on fungi during the disaster are limited because, as discussed in CFF 36 Supplement 5, the largest number of fungi often appear about 2 days after commencement of significant rain. Winds and rain during the critical period were so intense that field observations virtually stopped. Landslides and flooding closed many roads and with wind gusts over 100 km/hr it was just too dangerous to undertake field work.

Based on the limited information available:

- There was a sudden and diverse flush of fungal fruit bodies on the second and third days after rain commenced, but the fruit bodies were quickly waterlogged, then pulverised by the intense downpour. During this period a few *Entoloma, Hygrocybe* and *Leucocoprinus fragillisimus* appeared and *Marasmiellus luxurians,* a *Crepidotus sp* and possibly *Russula* aff. *erumpens* in the Cairns Botanic Gardens but all were very short-lived, being quickly drowned, super-saturated or pulverised. *Phallus indusiatus* was conspicuous by its absence – it usually appears early after any rainfall.
- From day 3 onwards the soils were waterlogged and fungal fruiting on soil stopped. Similar observations about north Queensland soils becoming toxic with excessive rainfall were discussed in Muir & Palmer (2018) and a similar disruption to mycorrhizal activity has been observed in willow coppices in England (Barnes *et al*., 2018). These observations suggest that fungal activity adversely affected by excessive rainfall may be a widespread and normal outcome. More Australian observations are needed.
- Perennial fungi that lived on trees and logs began to show new growth and common genera like *Filoboletus, Mycena* and *Pluteus* became temporarily abundant on wood but were quickly pulverised by the rain.
- There seemed to be a greater number of mould species than usual, and less macrofungi. Soft species like *Tremella* and *Auricularia* were pulverised and tough but thin fungi such as *Cymatoderma elegans* and *Lentinus sajor-caju* were torn or flattened.



Guardian graphic | Source: Bureau of Meteorology

Experts say it was not the intensity of the cyclone that has made Jasper stand out, but its slow speed and the incredible amount of rain it generated. Photograph: Liv Cole

Barron River flood levels during Cyclone Jasper.

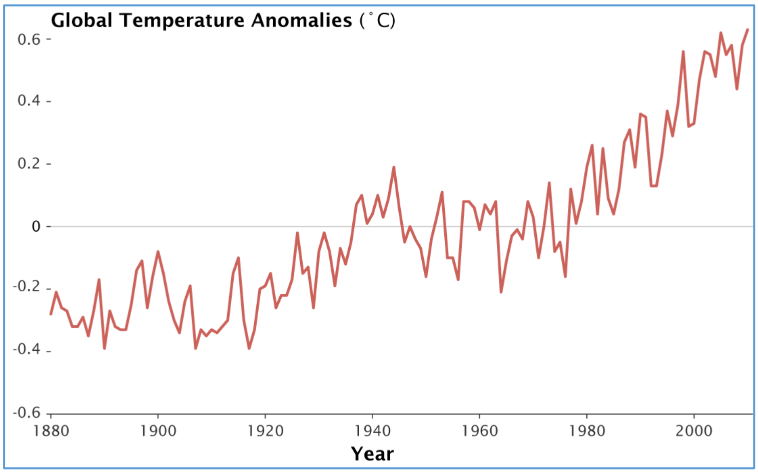
In summary, despite the large amount of rain that fell between 13 and 18 December, there were few fruiting bodies able to be collected and identified during the 2023 BOR cyclone period.

Rains reduced to a light drizzle for two days (19th and 20th December 2023), then stopped, but there were almost no new fruiting bodies. After two dry days a "Heat Wave" (as termed by Bureau of Meteorology) commenced. Daytime shade temperatures in the mid-30s°C (I recorded a 48°C full-sun temperature one day) and low humidities followed for almost three weeks. Vapour Pressure Deficit (a measure of dryness of the air – see CFF No 35 Suppl. 4) was above the critical level of 10 millibars for 18 days, even on most nights, and reached 24 millibars (extremely dry) on several occasions. Any fungus that had survived the rains quickly dehydrated and shrivelled with the heat and extreme low humidity.

The next period of **substantial** rain (91 mm on the first day followed by 330 mm over the next 10 days – Whitfield data) did not commence until 12 January 2024, 23 days after cyclone Jasper. Searches for fungi by several people, in numerous locations, found the usual suspects, especially shotgun and opportunistic species (see CFF 33 Dec. 2022 or CFF No 35 Suppl. 4) but in low numbers. Apparently the usual BOR burst of fungi was largely destroyed and that fruit body production during the follow-up rains was about the same numbers as normally occurred during follow-up events in previous years. In other words, the great burst of fruit bodies that normally occurred at BOR was largely lost this 2023/2024 wet season.

Was Cyclone Jasper, an unusually slow-moving and extremely high rainfall system, in any way caused or influenced by Climate Change? The answer is "yes" as discussed below in the next article. Some research has shown that slow-moving, high rainfall systems are already happening elsewhere (Kossin 2018, Sun *et al.* (2020), Welch 2018). We can expect both more cyclones and more flooding in the future.

We know sea surface temperatures have been abnormally high to the north-east of Australia and climate scientists know that for each degree of global heating the atmosphere can hold about 7% more moisture that is then available to fall as rain. When water vapour condenses it releases heat that can add more energy to storms to suck up more moisture. Double to triple this rate of 6-7% per degree of warming has already been observed in Australia and some scientists are advising that land planners should consider that each degree of warming could increase rainfall in some regions by as much as 15%.



Change in global temperature since 1880 Source: NOAA

Implications for fungi are numerous. Here are just a few:

- Extreme events may destroy fruit bodies (already observed) before they set spores.
- Longer periods between rain events, or increased temperatures, may disadvantage fungal species with certain life strategies, such as bell-curve or wait and see species (already observed).
- Shorter periods between rain events may favour moulds rather than macrofungi and may favour opportunists over wait and see species (already observed?).
- Perhaps increasing or decreasing rain events may favour, for example, decomposer/recyclers over mycorrhizal species, thereby changing mulch, compost and fallen timber ecology in natural environments.
- Migration of host vegetation towards cooler conditions (either higher latitudes or higher elevations) and its associated fungi may affect other non-migratory plants that use the same mycorrhizal associates.
- Interactions between plant and fungal species may change, affecting plant health, pollination, and fruit set. This may be especially important in crop and food plants and in feed for livestock. Changes in the flavour of fruits, resulting from changes to endophyte fungi, have already been observed.
- The contribution of both plant and fungal partners to the global carbon cycle may change, perhaps creating a feed-back loop that releases even more carbon dioxide into the atmosphere.

For further reading try; Pickles et al., (2011) and Young & Fechner (2008).

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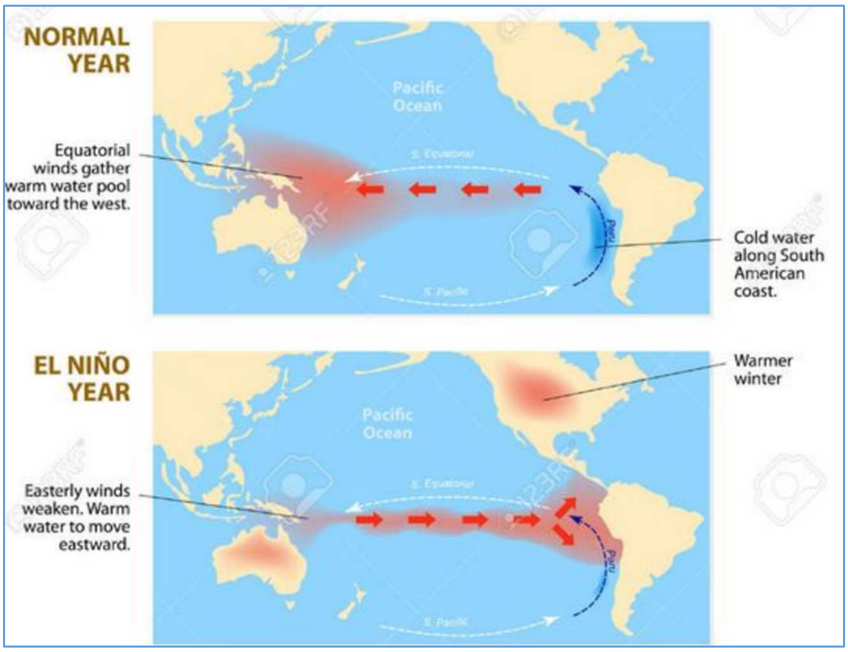
HOT, DRY, AND TWO CYCLONES

This year (2024) is, as you are probably aware, an El Niño year, but what does that mean for the climate? Bear in mind that the following is an oversimplification, but, in short, it all comes down to what are called El Niño (Spanish for Little Boy) and La Niña (Spanish for Little Girl) events. These are opposite phases of what is known as the El Niño-Southern Oscillation (ENSO) cycle. The ENSO cycle is a scientific term that describes the differences in water temperature of the Pacific Ocean between Tahiti and Darwin. These temperature fluctuations affect wind, clouds, and ocean temperatures in the eastern and central Pacific. This makes ENSO one of the most important climate drivers in our region. Outside of Australia, ENSO also affects every single other continent in the world, particularly South America, Africa and Asia.



In a "normal" or La Niña year there are strong trade winds: so named because they blew trading sailing ships across the Pacific from east to west. A La Niña period emphasises this: the winds blow stronger from the Americas to Australia across the Pacific Ocean (see map). The trade winds blow some of the surface water to Australia, the sun warming the surface water as they blow.

This means we start to see warmer-than-usual waters collect around Australia and Indonesia. Warmer waters bring more evaporation, which leads to more condensation, which leads to more clouds and rain. We can thank La Niña for those heavy downpours and flooding events that we saw during winter in south-east Australia over the last few years. The last El Niña event lasted three years and was partly to blame for the horrendous bushfires down south. Three warm, wet years promoted strong growth of vegetation and then summer lightning storms set the bush alight.

Now, Australia has just come into an El Niño phase, characterized (theoretically) by the presence of cooler than normal sea surface temperatures near Australia and warmer water near South America (see map). This is usually accompanied by weakening of the easterly trade winds, less evaporation near Australia because the ocean is cooler, hence less clouds and so heatwaves and drier or drought conditions prevail. The heatwaves we have already experienced here in Cairns (see the previous article), and there has been several bushfires on the Atherton Tablelands.

But – so far, this El Niño has been a little different. The global climate and oceans have heated up significantly because of climate change. While the water is warmest well out in the Pacific and near South America, as expected, our normally cooler water near Australia is still warmer than usual. After Australia's driest September and October on record, Queensland has had cyclones Jasper and Kirrily, and extreme rain events. By contrast Victoria has had flooding rains which are not expected in an El Niño year. While other factors can contribute, these warm oceans are likely the main culprit behind our weird and disturbing summer.

So what about the cyclones? There have been 207 tropical cyclones along the east coast of Queensland since 1858, and, on average, four to five tropical cyclones per year. However, historically, there has never been a close correlation between El Niño **or** La Niña and cyclones, although, in general, cyclones in the vicinity of Australia are <u>reduced</u> in number during the El Niño phase of ENSO. Additionally, number of cyclones each year has been steadily declining since the 1970s. That being said, now the western Pacific waters are warmer than in the past, and global warming continues to rise at about 1.18 to 1.35ºC per year (Lindsey & Dahlman 2024). Who can predict what is going to happen in the future? The only thing we can be sure of is that it is not looking good and efforts to reverse the climate trend are half-hearted or non-existent.

Warm ocean waters, no matter where they are, are necessary to fuel a tropical cyclone. An atmosphere warm at the ocean surface but which cools quickly with height is potentially unstable, because warm air normally rises. The force of the Earths spinning unbalances the winds. Inflow into the low-pressure bottom part of a cyclone is deflected clockwise (in the Southern Hemisphere) and the partial vacuum of the low pressure zone is quickly filled.

Because cyclones in the Southern Hemisphere spin in a clockwise direction, the strongest winds and highest rainfall are on the south side of the cyclone as it approaches the coast from the east. Cyclone Jasper passed between Port Douglas to the south and Cooktown to the north, so Port Douglas received the greatest impact. Cyclone Kirrily crossed the coast between Ayr to the south and Ingham to the north, so Ayr received the greatest impact, although Kirrily was a relatively weak cyclone..

Lindsey R & Dahlman L. 2024). Climate change: global temperature. www.ncei.noaa.gov/access/monitoring/monthly-report/global/202313

FUNGI CAUSE RAIN

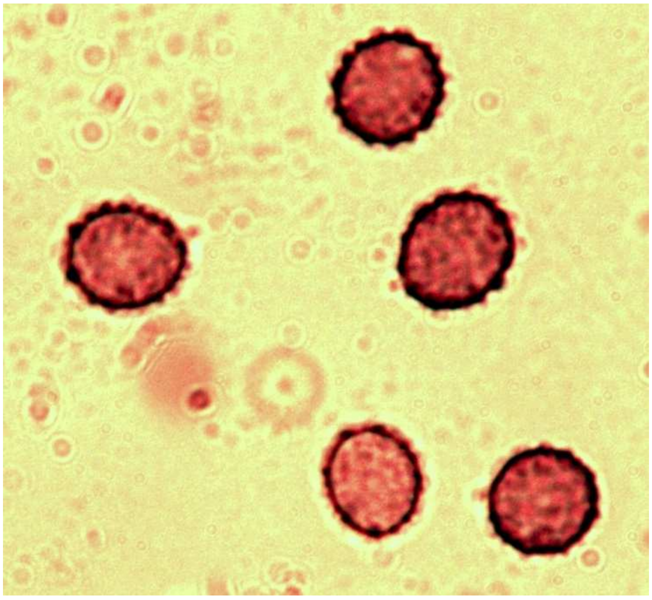
Having just looked at the disastrous start to the current wet season here in Cairns, and how that rain affected fungi, it seems appropriate to look at how fungi have a role in causing <u>normal</u> rain - not devastating cyclones!

Firstly, what is normal rain? Rain forms in a series of steps. Firstly, water vapor is added to the air from pre-existing raindrops, from daytime heat evaporating water from the surface of oceans, lakes, rivers and swamps, transpiration (breathing) water output from plants, by cool or dry air moving over warmer water, and even from winds carrying water into mountains and the water condensing as it rises and gets cooler.

Next, the water vapor begins to condense on what are called cloud condensation nuclei (CCN). Such nuclei can be pollen, fungus spores, dust, ice, salt crystals from sea-winds, smoke particles or even pollution such as particles from car exhausts. Brightly coloured CCN, such as red dust or green algae, can cause coloured rain but, because CCN are so tiny, colour is rarely visible. The nuclei, and the condensed water around them, form clouds.

The next step is called coalescence – joining together. Coalescence occurs when water droplets fuse to create larger water droplets. Air resistance typically causes the water droplets in a cloud to remain stationary, but when air turbulence occurs, water droplets collide with each other and join, producing larger droplets. As these larger water droplets descend, coalescence continues, so that drops eventually become heavy enough to overcome air resistance and they then fall as rain.

Coalescence generally happens most often in clouds above freezing temperature. In clouds below freezing temperature ice crystals form and may become heavy enough to fall. The ice crystals then melt on the way down and become rain – if they do not, they fall as hail. The key to rain, therefore, is the CCNs.



***Russula* spores – ideal as CCNs**

A single common mushroom can release 30,000 spores every second and so millions of tons of fungal spores are shed into the atmosphere every year. Although plant spores (e.g., from ferns) and pollen grains also contribute, it has been estimated that 50 million tonnes of fungus spores are dispersed in the atmosphere every year (Hassett *et al*., 2015) and that they are particularly powerful initiators for raindrop formation in clouds. This may be important in ecosystems such as rainforests that support large populations of mycorrhizal and decay/recycler fungi. Some scientists have raised concerns about the sustainability of forests that depend on heavy rainfall because land clearing reduces overall fungal populations and that, in turn, may be reducing rainfall to the extent that even uncleared forests located elsewhere may be affected.

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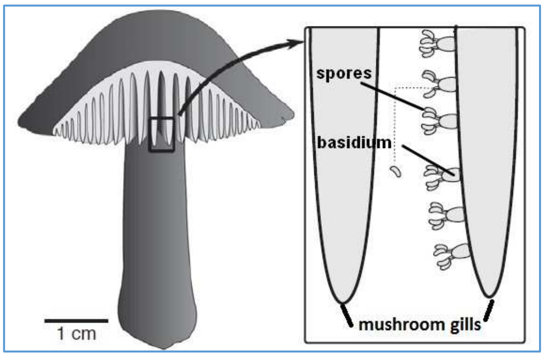
WATER ALSO PLAYS A ROLE IN SPORE RELEASE

Spores are discharged from the gills, pores, or spines of fungi by a catapult mechanism powered by the rapid movement of a drop of fluid over the spore surface. This fluid is called Buller's Drop in tribute to "the Einstein of Mycology," A. H. R. Buller (1874–1944).

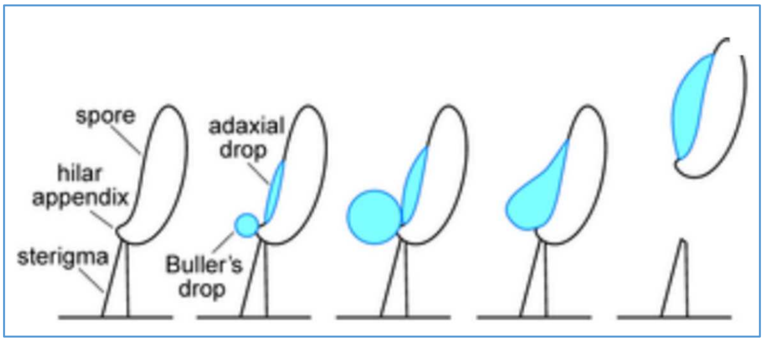
The spores are attached to a tiny protrubance called a sterigma and the sterigma, in turn, is attached to the top of the basidium (plural basidia), the projections that form all over the surface of the gills and pores of the fungal group that is named after them, the basidiomycetes.



Water condenses onto a protrubance at the base of the spore (called the hylar appendix) where the spore is attached to the sterigma. This is Buller's Drop.

The drop is formed because of the condensation of water on the spore surface caused by the production of mannitol and other fungal sugars that absorb water out of the air.

Water also condenses on the adjacent spore surface. The merger of Buller's drop with this second volume of fluid (called the adaxial drop) causes the spore to be released and be fired off into the air. The spore may be launched at up to 1.8 m/second, nearly 4.5 km/hour.

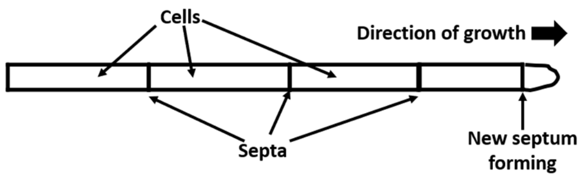


Schematic diagram of how Buller's Drop works.
Source: doi.org/10.1371/journal.pone .0140407.g001

The spores fall in the narrow spaces between the gills or inside the pores of the fungus fruit body and are dispersed by airflow around the mushroom cap. Some of the sugars are carried into the air along with the spores in such quantity the sugar can even be detected in air samples above tropical forests.

WHY DON'T THE GOODIES INSIDE HYPHAE LEAK OUT WHEN I CHOP THEM WITH A SHOVEL?

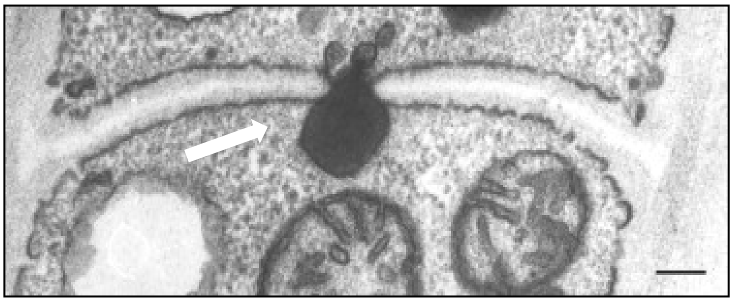
The hyphae produced by fungi are under very high internal pressure, about 1200 psi (your car's tyres are about 30-35 psi) so why don't the hyphae squirt all the goodies out when you put a shovel through them? Well, different types of fungi have different tricks. Some have complete cell walls (called septa plural or septum for singular), i.e., there is no connection between the cells, so that when you cut one, the remaining wall of the cell you cut just becomes the new end of the hypha.



In others the cell walls are minutely perforated, allowing molecules to pass between cells but so tiny the holes stop the structures within the cell (called organelles) from passing through. Effectively a sieve filtering out the big bits!

The interesting tricks are in the more evolved fungi; the ascomycetes and the basidiomycetes. These fungi have a large hole or pore in the septum walls, allowing inter-cell communication for protoplasm (the goop inside cells), minute cellular structures and organelles, chemical molecules, and water to flow through the hypha like a hose. When these hyphae are cut, or break through natural causes, it is necessary for the fungus to plug the hole immediately or its internal pressure would drop, and it would lose part of its protoplasm, i.e., it would leak!

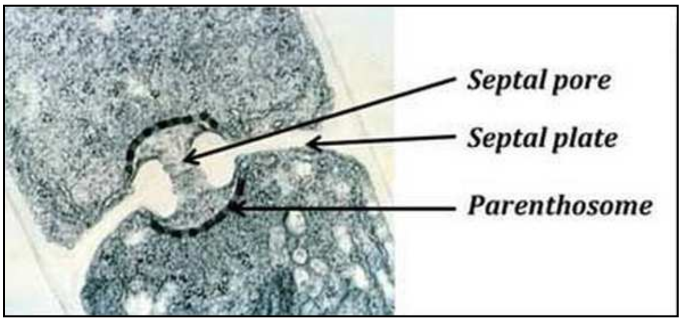
In the **ascomycetes** this is achieved through structures called **Woronin bodies** which act as plugs (see picture of a septum between two cells with the Woronin Body arrowed). Logically, with high internal pressures, it could be expected that the throughflow of cytoplasm out of the leaky cell would cause Woronin bodies further back along the hypha to flow forward and block the hole.



A Woronin body plugging the pore in a septum. Source: Wikipedia

Another hypothesis is that to achieve this quickly, the ascomycetes may have special protein strings within the cells and these contract very quickly to bring the Woronin Bodies into place to become 'bungs' or corks that plug the hole – a very clever solution but not yet verified. There is some evidence that the fungus actively prevents the Woronin Bodies from accidently blocking the septal pores when it doesn't want them blocked. More research is needed to clarify the processes involved.

The **basidiomycetes** have a different strategy called a **dolipore septum**, from the Latin dolium = large barrel or cask. The central canal (pore) of this structure has a barrel-shaped swelling around the pore. This structure is typically capped on either side by specialized membranes, called 'parenthosomes' (after their parenthesis - bracket-like - appearance under a microscope) or simply 'porecaps'.



A dolipore septum showing the swellings at the septal opening and the parenthosomes. Image from Shew.

The parenthosomes may have minute pores in them, one hole or no hole at all. When the hypha is injured, these parenthosome membranes collapse and seal the open ends of the swelling in the septum, performing the same function as the Woronin Bodies of the ascomycetes in blocking the damaged hypha. Clever little critters, aren't they?

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