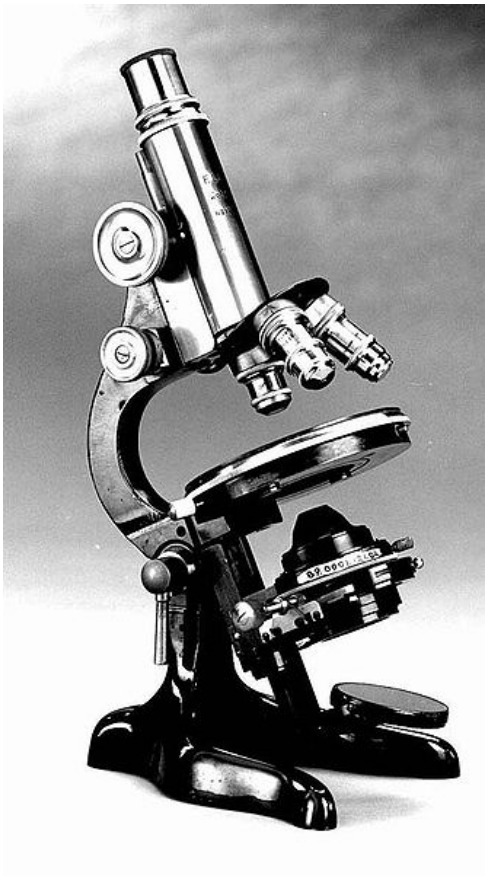
Notes On **Microscopy** & How To Get Started. Scope!

Identification Microscopy of Gilled Mushrooms

M. No-Line 2017 c.e.



Microscope photo courtesy Wikimedia Commons

Mycologists and Respected Contributors in Alphabetical Order: Andrew Baldwin, Leah Bendlin, Caleb Brown, Tim Cannon, Alonso Cortés-Pérez, Jason Hollinger, Linas Kudzma, John Robinson, Alan Rockefeller, Nino Santamaria, Anton Soklič, and Mike Wallace.

Preface

Many books, journal articles, websites, and personal communications have made their way into the wider world over the past decade and a half relating to microscopic techniques for *gilled mushrooms*. All known sources to date are incomplete (or include minor issues) and lack knowledge needed for a beginning mycologist to accurately and confidently describe all microstructures used in taxonomy. This text is an attempt to provide the new mycologist with an intuitive guide to perform microscopic identification on gilled fungi, with the inclusion of a sizable glossary. This online, free guide is also a focused approach targeted on gilled fungi without including other types of fungi.

Microscopy has been performed on gilled mushrooms for over a century now. Many authors have provided their techniques. Among the hard copy authors who deserve their proper place in this lineage are Dr. Cornelis Bas, Dr. A.H. Reginald Buller, Dr. Heinz Clémençon, Dr. G.A.C. Douwes, Dr. David Johnson, Dr.

David Largent, Dr. Jack Marriott, Dr. William Murrill, Dr. A.F.M. Reijnders, Dr. Rolf Singer, Dr. Alexander H. Smith, Dr. J.A. Stalpers, Dr. Else Vellinga, Dr. J.A. von Arx, and Dr. Roy Watling. There are many other author names which deserve to be mentioned, and as I learn them I will make an effort to update this document. I should also note here that I do not present this information as if it were new and of my own discovery. I present this information as a companion text to those of other mycologists, and as a tool to help others know the gilled fungi on our Earth.

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Introduction

A compound (biological) light microscope will provide you with more specific information to find out what species of mushroom you've collected. You can also share this information with others using sites like Mushroom Observer.

Among the things you can do with a microscope: View, measure, and describe the presence of spores, cheilocystidia, pleurocystidia, and basidia.

Purchasing An Introductory Microscope

Order a compound light microscope with 4x, 10x, and 40x objectives ALONG WITH a 100x oil objective. It should be binocular (or trinocular) so it's easy on your eyes. Here's a good introductory model:

Above: The Model B100B-MS from Amscope.com

Other needs: Immersion oil, reticle, stage micrometer measuring-calibration slide, slides, cover slips,

and 009 razor blades.

You will also want some type of microscope objective cloth to remove the oil from the lense. The little pieces of paper placed in between microscope slides will work as a short term alternative. Clean cotton will also work. Please first consult with the microscope manufacturer or the institution who owns the microscope before applying cleaning supplies to a microscope.

You can initially use H2O (distilled water is preferred) to *mount* with. You will want a 2oz dropper bottle for this. Eventually you will want other materials, including 5% KOH and 0.1% Congo Red stain - which we'll discuss further down. Depending on your location, you can purchase stains from a number of different stores. In the United States try Ebay, Amazon, HomeTrainingTools, and chemical suppliers. In the United Kingdom try micro-science. Other areas within and outside of Europe can try Electron Microscopy Sciences and Myco-Shop. There are many other suppliers as well.

How To Use A Microscope

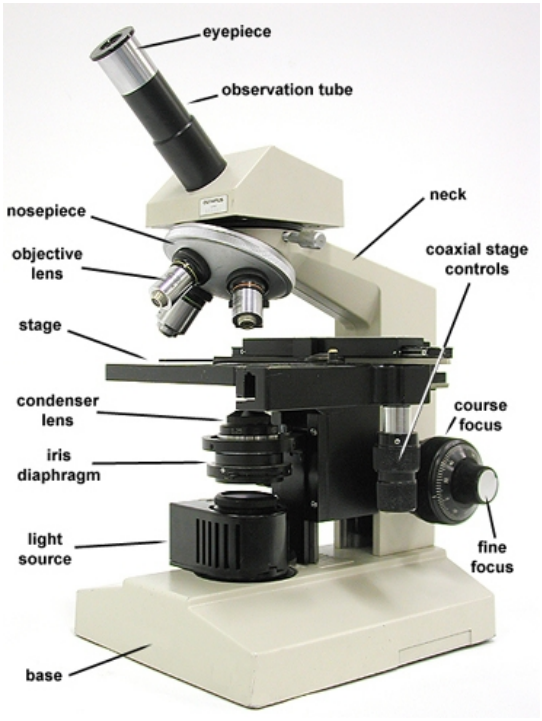
A microscope might look like a challenge. It's not. With the right introduction it can easily be understood. The most important thing you need to know is this: It simply magnifies what you're looking at.

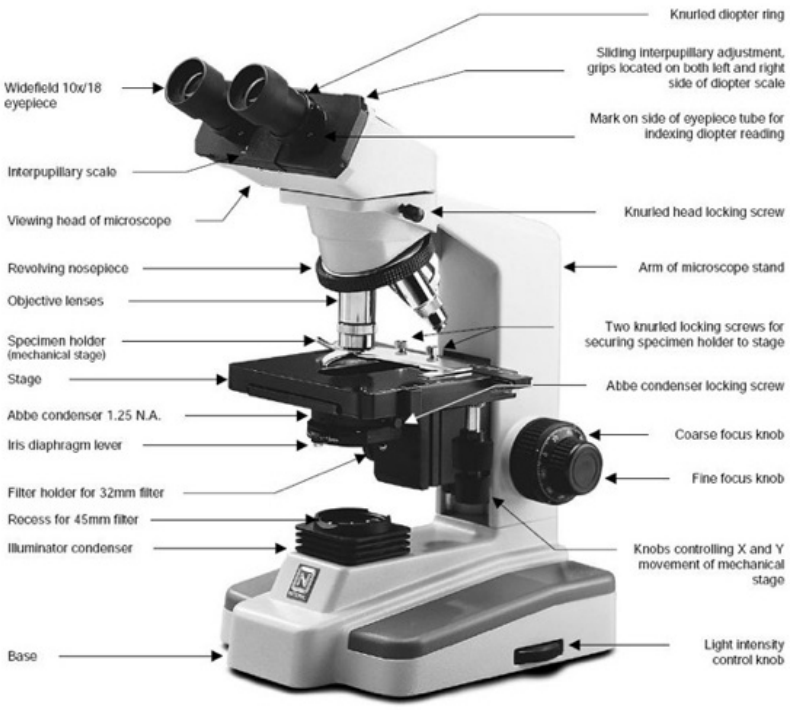
Below: There are two areas on your microscope that you should first understand:

(1) **The eyepieces** (usually 10x eyepieces or 20x) - (x means magnified that many times. For instance, 20x means 20 times your plain sight).

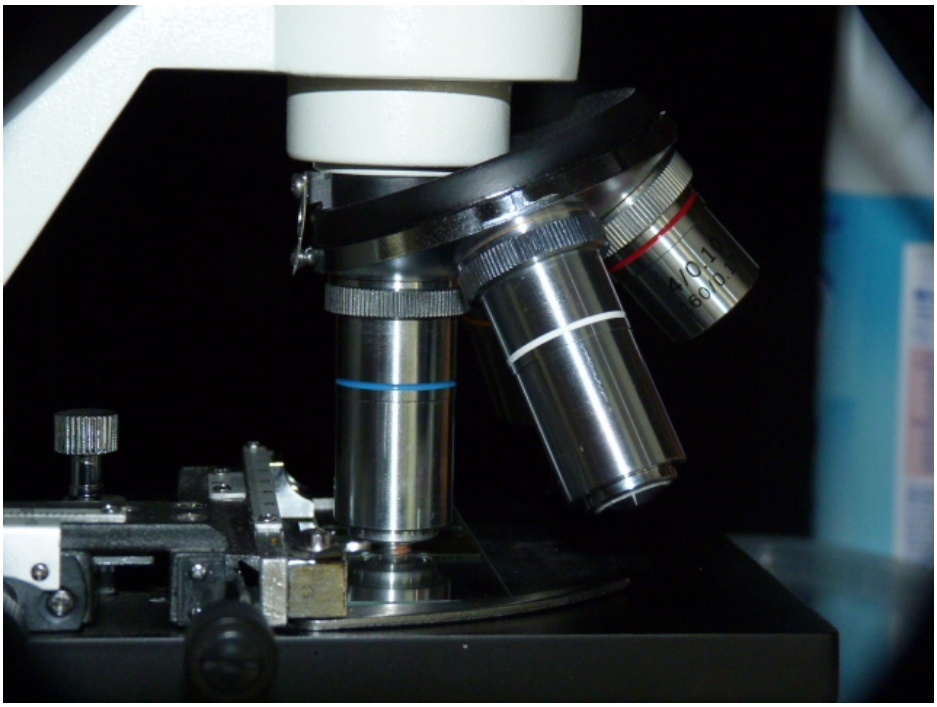
(2) **The four objectives** - Most compound microscopes come with four objectives for additional magnifications (a 4x, 10x, 40x, 100x). So if you have the 10x eyepiece in with the 4x objective selected that would be 40x total magnification. Likewise, if you have the 10x eyepiece in with the 100x oil objective the total magnification is 1000x.

Below: Two diagrams (one monocular and the other binocular) showing the basic parts by name



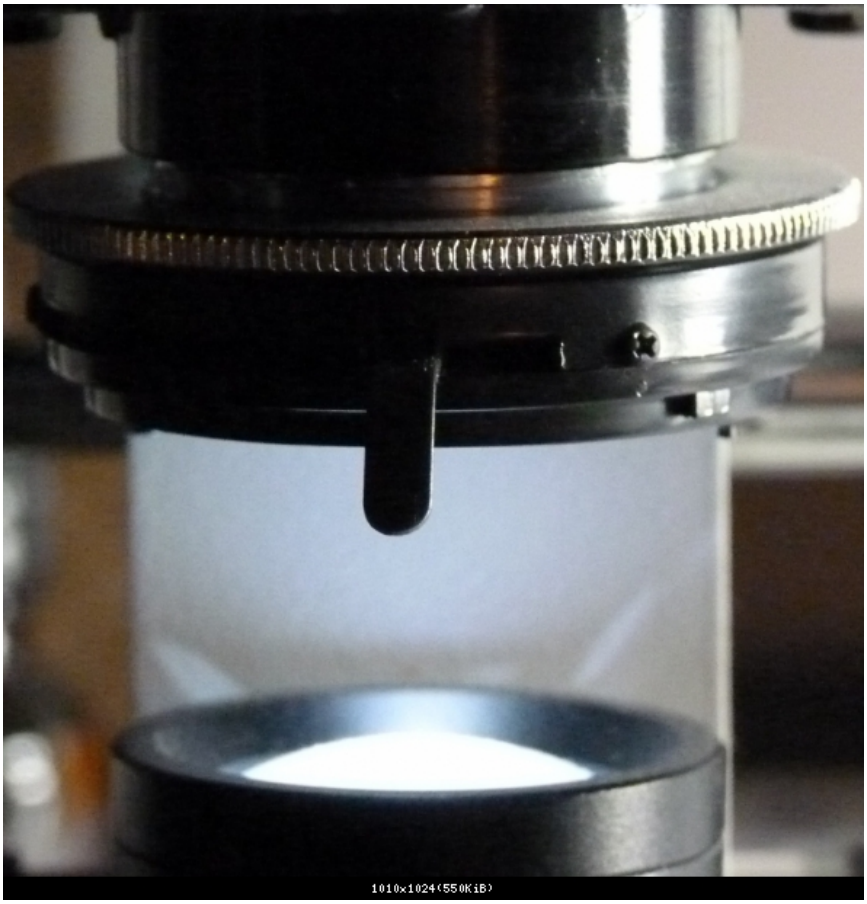


Below: The objectives are connected to a rotating *nosepiece* which allows the user to transition from one objective to the next:

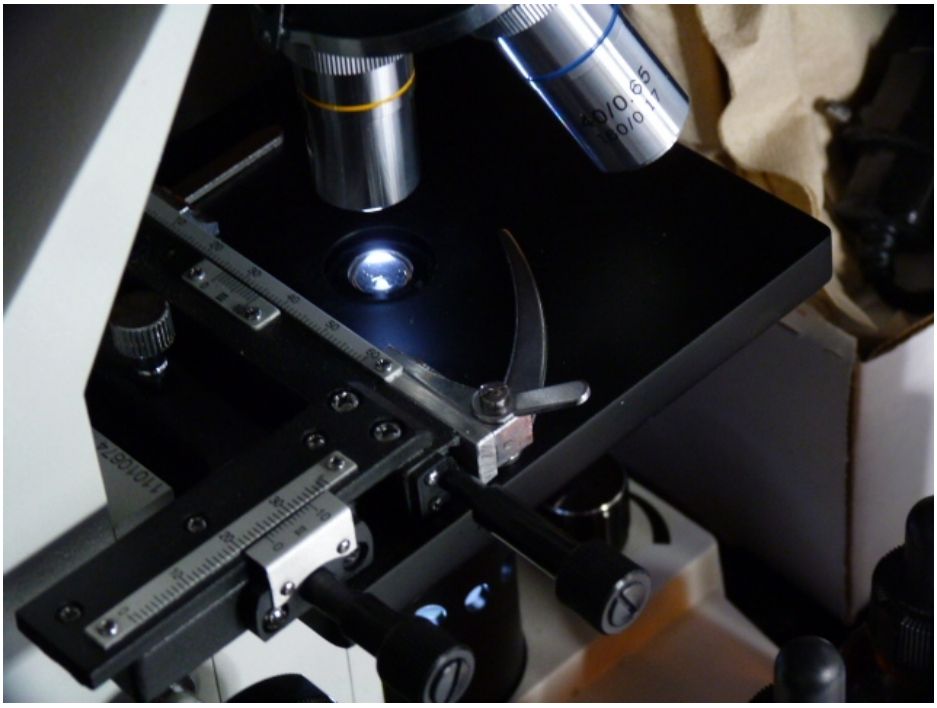


Below: The larger "course focus" knob will make significant adjustments to focus (the smaller "fine focus" is used to make final adjustments):

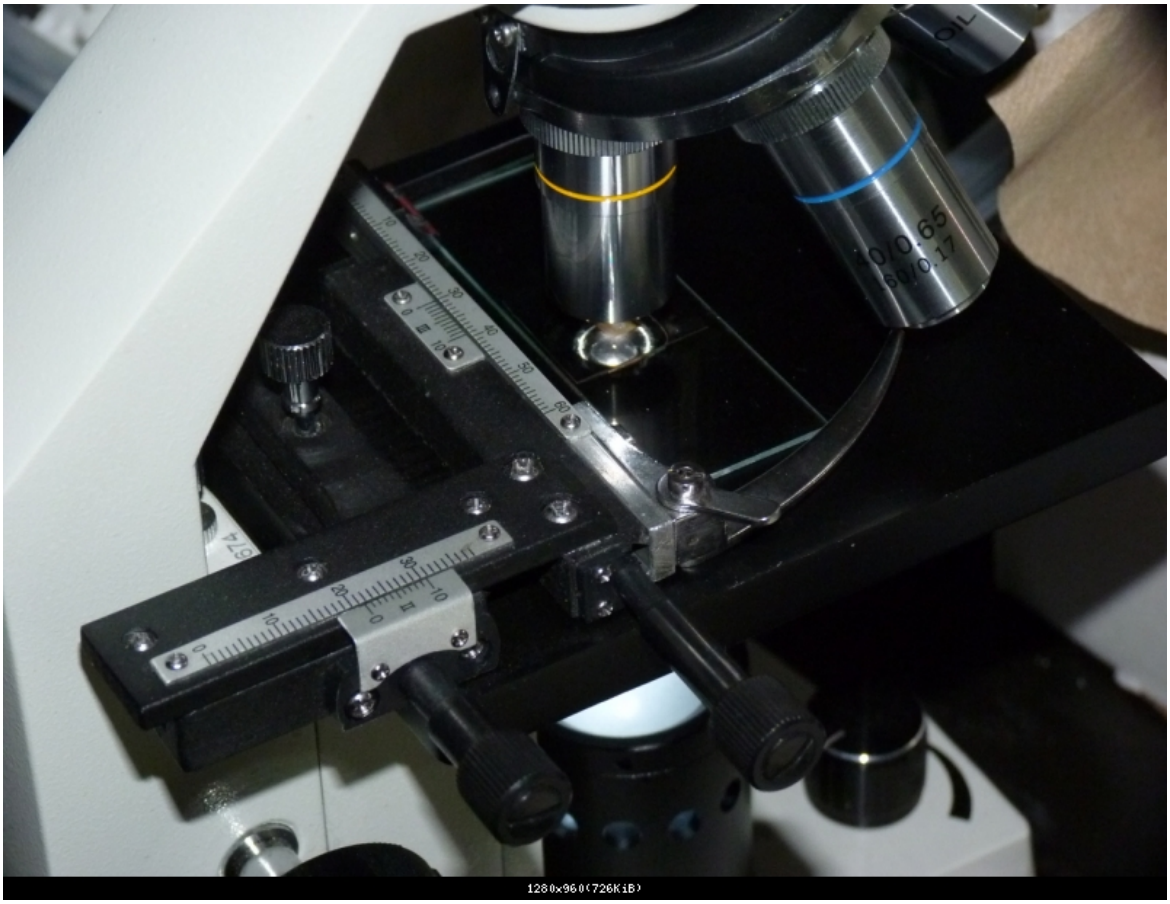
Below: The "condenser diaphragm" (or iris diaphram) (above the light) has a left-to-right switch (on this model) that will adjust the width (and amount) of light from your light source:



Below: The "mechanical stage" (the large black square) with a chrome slide holder. Also notice the two black dials for left/right adjustments and forward/backward adjustments. Compare to next image.



Below: A prepared slide sits on the mechanical stage and is held in place with the chrome slide holder



Below: Microscopes which are binocular (or trinocular) will require a personal adjustment to the distance between the two eyepieces. This is called *interpupillary distance*. Many microscopes will allow you to easily, physically adjust the distance by moving the oculars directly outward or inward.

You want to be able to see spores, cheilocystidia, pleurocystidia, and basidia - *and* you want to be able to measure them. There are two ways to do this - **1.** With a microscope camera/digital imager and a pixel measuring program for Mac or PC (or) **2.** A 10mm-ruler reticle inside of a 10x eyepiece.

How To Use The Oil Objective

Above: Cargille Type A immersion oil

The oil objective really only requires two additional steps compared to the other objectives: Adding oil and cleaning the oil from the objective when you're done. To use the objective you'll need Cargille immersion oil (Type A) and I personally recommend Zeiss Lens Cleaning Wipes for cleaning the objective after you're done. All that needs to be done to use the 100x oil objective is follow these very easy

instructions: Once focus is obtained with the 40x objective, rotate in between the 40x objective and the 100x objective. Place one drop of oil directly on-top of the cover slip of the slide at the center where the light peers up. Then simply rotate the 100x objective and make a small fine focus adjustment. Once finished observing your specimen, the objective is cleaned by rotating halfway again in between the 40x and the 100x objectives, and gently patting down the 100x objective with a lens cleaning wipe.

Below: Zeiss Lens Cleaning Wipes (Designed for "eyeglass optics and high quality optics" including microscopes)

Making Adjustments To Obtain A Clear Field Of Vision

There are at least three things that can become crucial in getting a better field of vision (besides stains and optics). These three things are iris diaphragm adjustment, directional adjustment, and on some microscopes the light level (which is not the same as the iris diaphragm). Once you have a section that is hydrated and stained (discussed further down) it can make a huge difference to start by turning the iris diaphragm all the way to its lowest setting. Move the specimen so that it is impacted by the light in the most advantageous way. Sometimes this means moving far to one direction so barely any of the section is seen and yet the most important part is still visible. Lastly, if the iris diaphragm happens to be at its lowest possible setting and there is still too much light, you may turn the actual light dial setting down until visibility is achieved.

Measuring With A Reticle Through An Eyepiece

You can manually perform measurements directly with your microscope using an eyepiece that has a reticle installed in it.

The first step to measuring with a *reticle* is calibration using a *stage micrometer*. This is done once each year usually.

Below: An image of a *stage micrometer* with its case. A stage micrometer is simply a microscope slide that has a microscopic ruler in the center of a circle. The ruler has many "line divisions" just like a regular ruler - only the distance is 0.01mm from one line to the next (0.01mm is the same distance as 10 microns).

Your microscope comes with 10x eyepieces. In most cases, you'll have to purchase a reticle and place it inside an eyepiece or you can simply purchase a new eyepiece with one already installed.

The reticle is a ruler without any numbers on it - just lines (called divisions) which you'll need to measure in order to know the distance between each division. This is the purpose of the stage micrometer and the reason the stage micrometer is used only once per year. This process is called calibration.

In order to calibrate it you need a stage micrometer slide. If you buy a typical stage micrometer it will have a 10-micron-per-line-division ruler (although it'll say 0.01mm per division which equals 10 microns.

Once the stage micrometer slide is on the stage of your microscope go ahead and first focus using the 4x objective, then rotate to the 10x and refocus, then the 40x and refocus, then do a "half rotation" and add one drop of immersion oil on the slide where the light emerges, and now rotate into the 100x oil objective. Regain focus so you can see both the reticle's ruler and the stage micrometer's ruler.

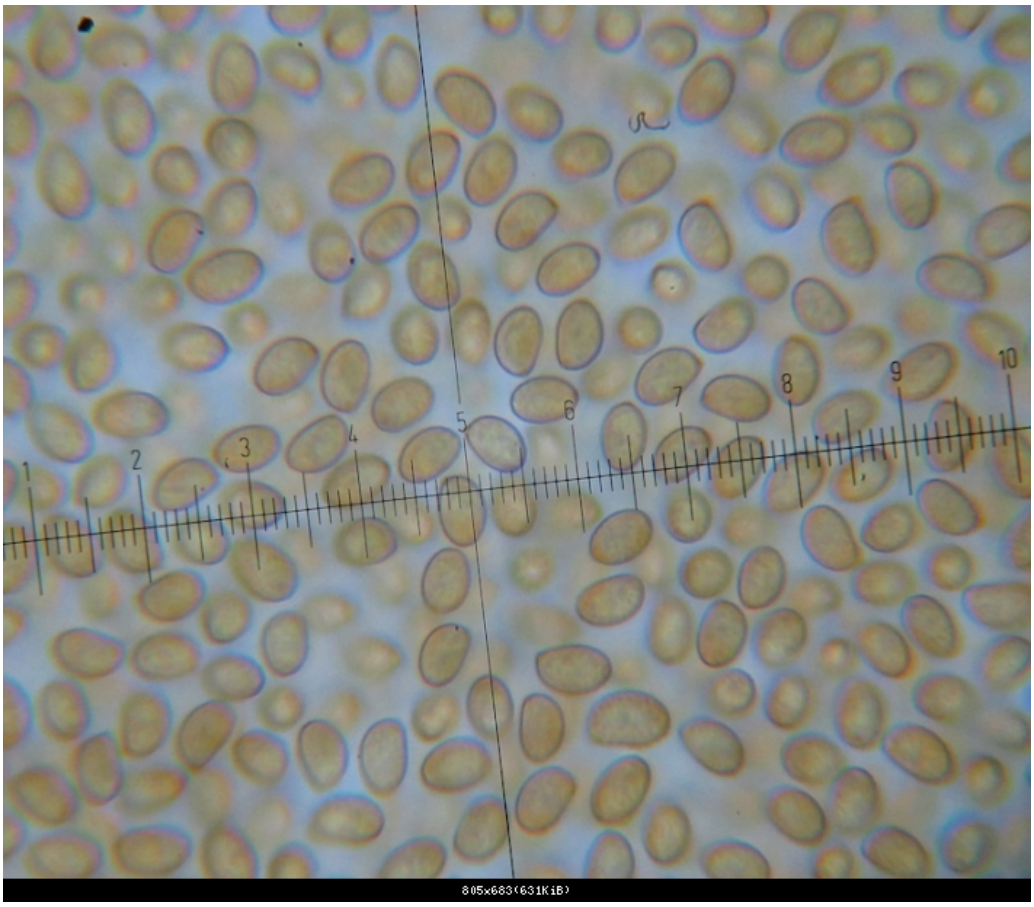
Determine how many reticle divisions are in one stage micrometer division - and be as precise as possible. Write this info down or remember it. It will be a very reliable and fast way to measure spores and cystidia (and anything else) in the future. At 1000x (using the 10x eyepiece with the 100x oil objective) - more often than not 1 *stage micrometer* line division = 10 reticle line divisions (and since 1 stage micrometer division = 10 microns that means 1 reticle division equals 1 micron).

Tip: If the stage micrometer lines are thicker than the reticle lines, move the slide so one reticle line is in the center of one stage micrometer line.

Note: All of your measurements whenever possible should be done with the 100x oil objective, however,

there are occasions where measuring has to be done with the 40x objective and very rarely the other objectives. You can use the same procedure to calibrate (understand measurement) for each objective when this becomes necessary. You can put away the stage micrometer now for a long time. Calibration is performed when either new equipment is added or to re-check your initial calibration - usually once per year.

Below: A look through an eyepiece with a built-in ruler (ie reticle). In this instance, each line division (the space between two divisions) equals 1 micron. Spores and other cells can be measured this way (the old fashion way).



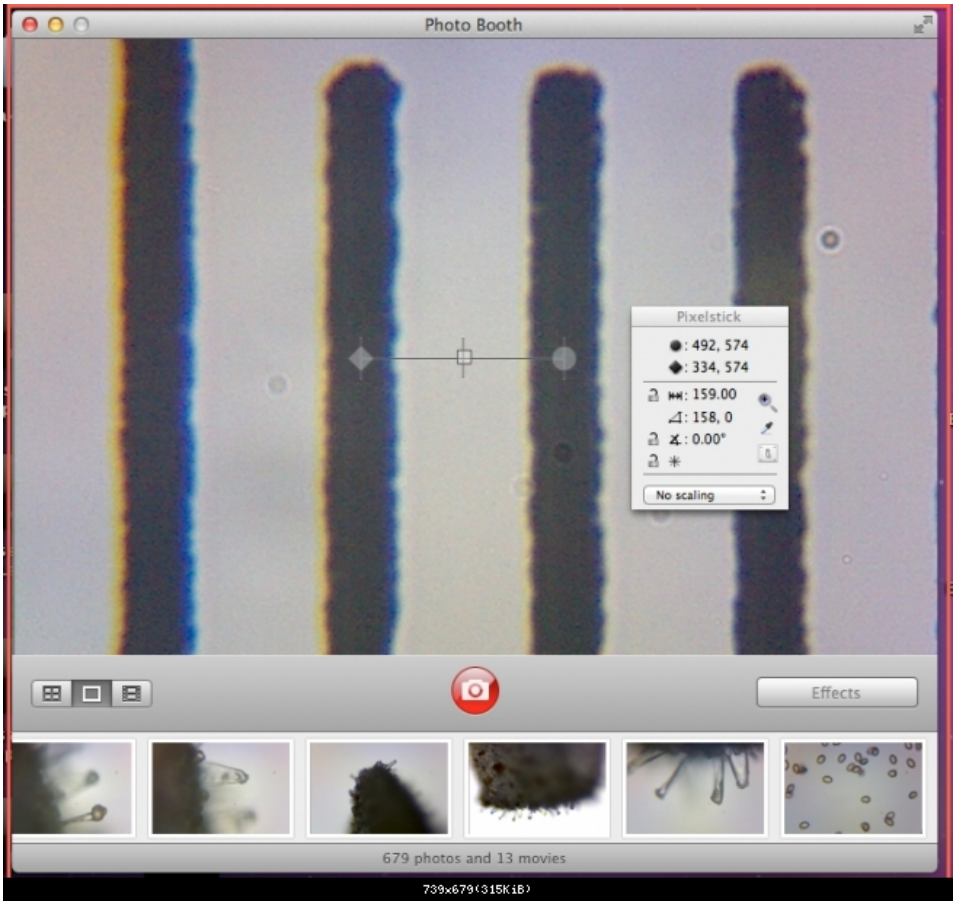
Manually Measuring With A Digital Imager (Microscope Camera)

Below: The Motic 3.0 MP digital camera (imager) installed in the trinocular port.

There are a fair number of new microscope cameras emerging and their prices are finally approaching the realm of affordability for the average student. A fair alternative to the more expensive imagers is the Celestron 44421. It does not come with measuring software. Directions on how to manually measure with it (and calibrate it) are provided below. Rather than performing non-digital measurements using an eyepiece and a reticle, software-based microscopy provides a much more welcoming method to study and measure cells.

There are different digital imagers available and different software programs. Some of these programs have their own measuring software, while others require the user to perform manual measurements. The instructions below will give anyone an understanding of how to perform manual measurements using pixels, but they are based on the Celestron 44421 and Apple's *Photo Booth* program.

Image Below: The Celestron digital imager was inserted in place of an eyepiece, then a stage micrometer was placed on the stage (for calibration). Each line division of the ruler on the stage micrometer slide is equal to 10 microns. After starting with the 4x objective and gaining focus we moved to the 10x then the 40x and finally the 100x oil objective. A picture of the stage micrometer's ruler was taken using the program *Photo Booth*. While still in Photo Booth looking at this photo, the measuring app *Pixelstick* is opened to measure from the middle of one division line to the middle of the next division line. This will allow us to do the math necessary to make measurements based on pixels - in microns.



The measurement in the photo above tells me (on my microscope with my 100x oil objective and my digital imager) that every 159 pixels on my iMac while in Photo Booth is 10 microns. (A more important note: I then divide 159 pixels by 10 microns for *15.9 pixels=1 micron*). Calibration is complete (for the oil objective). Now all I have to do is measure whatever items I want to and each time I can do the division needed to convert from pixels to microns. Keep this measurement math for constant reference.

One example: Let's say you measure one spore's length and width using Pixelstick. You measure 229 pixels by 129 pixels. You know based on your earlier work that every 15.9 pixels is equal to 1 micron. So to find the measurement you'll divide 229 pixels by 15.9 which gives you 14.4 (microns) for the length. Then do the same math to find the width. Your final measurements in this example should be 15.9 x 8.1 microns.

Remember that all settings need to be consistent from the time you performed calibration (for example the objective, the camera/imager, the program, and the computer screen). Make sure your desktop/screen resolution is also the same as it was for calibration. Also make sure the photo is being viewed at the same size & settings.

Final Note: Digital measurements should be confirmed for accuracy by measuring at least one identical item using an eyepiece with a reticle.

Measuring With Macnification (For Mac)

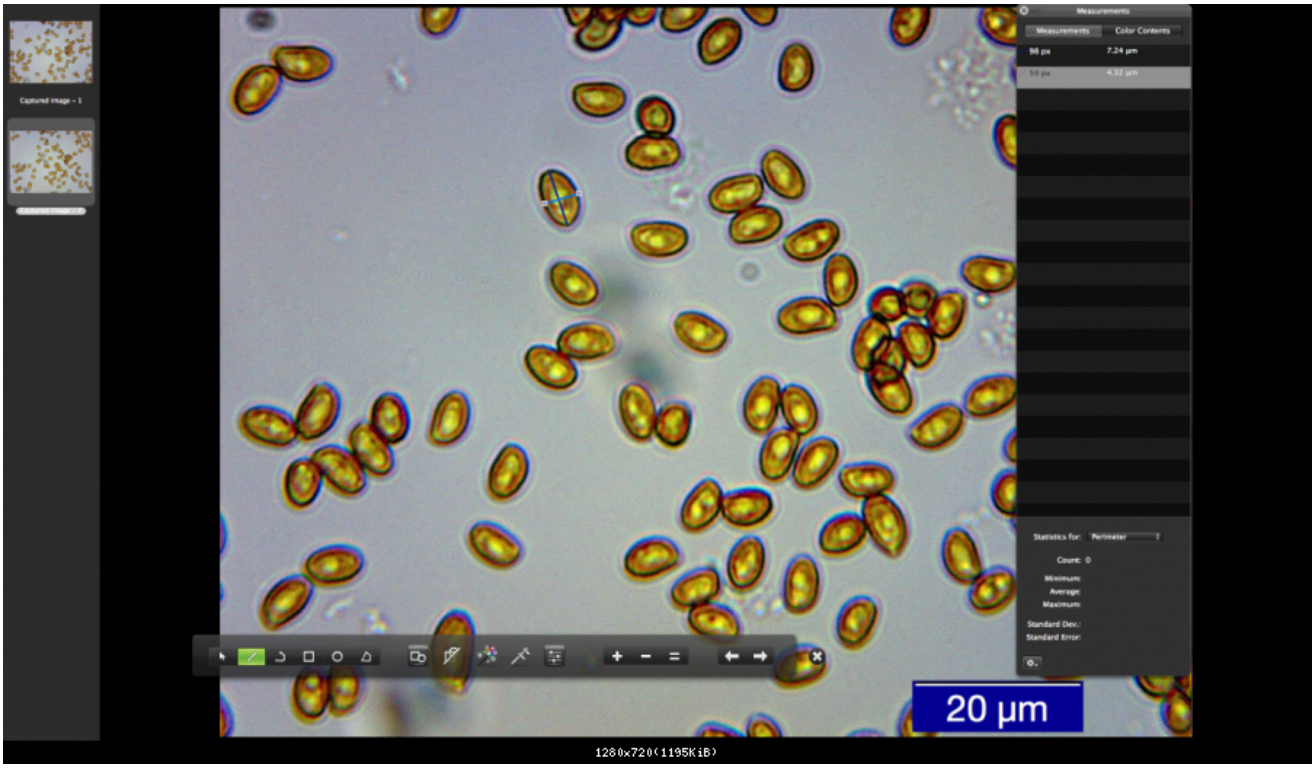
You can use a OS X and measure with a rather expensive app called *Macnification* 2.0.1. It is compatible with the Celestron 44421. This method will require you to calibrate each of your objectives with a stage micrometer within Macnification. These calibration settings are permanently saved within the program

and you can select which ever (objective) setting is appropriate for your image.

Once calibration is performed you can simply use your mouse and click from one end to another of any item(s) you wish to measure for length and width. These measurements will be displayed in microns within the app.

Other applications exist for alternative operating systems including: http://ach.log.free.fr/Piximetre/ and http://mycolim.free.fr/DOC_SML/mycoCLE/ ... ycocle.htm (Macnification will not be updated any longer so an alternative application should be considered).

Below: A screen capture (⌘ Shift 3) of Macnification



Final Note: Digital measurements can be confirmed for accuracy by measuring at least one identical item using an eyepiece with a reticle.

Measuring App Alternatives For Mac

If you want, run Windows side-by-side with OSX Mavericks without having to reboot. You have to first install Windows on your Mac.

Parallels Desktop for Mac and VMware Fusion both run Windows in a separate window alongside Mac OS X.

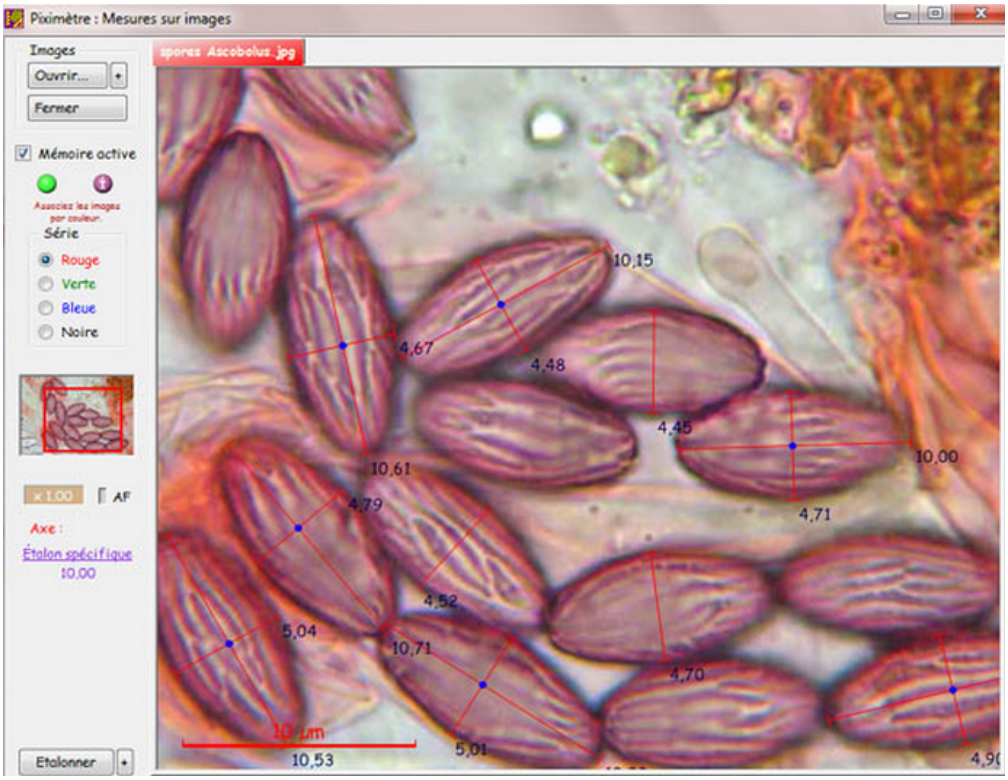
Then run the free app Piximetre in virtual Windows.

For those of you who want a Mac (OS X) version of Piximetre, I suggest that the mycologists among us eloquently email both of the esteemed creators: Jean Louis Cheype and Alain Henriot. Contact info is in their PDF: http://jlcheype.free.fr/articles_guyane/EntolomaArticles%20SMF2007-08w.pdf

If you only wish to send one sentence in your email, just ask them if they would please create a copy for the many Mac users in need of it.

Measuring With Pixemetre (For PC)

Pixemetre is a PC app for measuring spores: Click "Téléchargez Piximètre" at http://ach.log.free.fr/Piximetre/ and just walk thru the install in French.

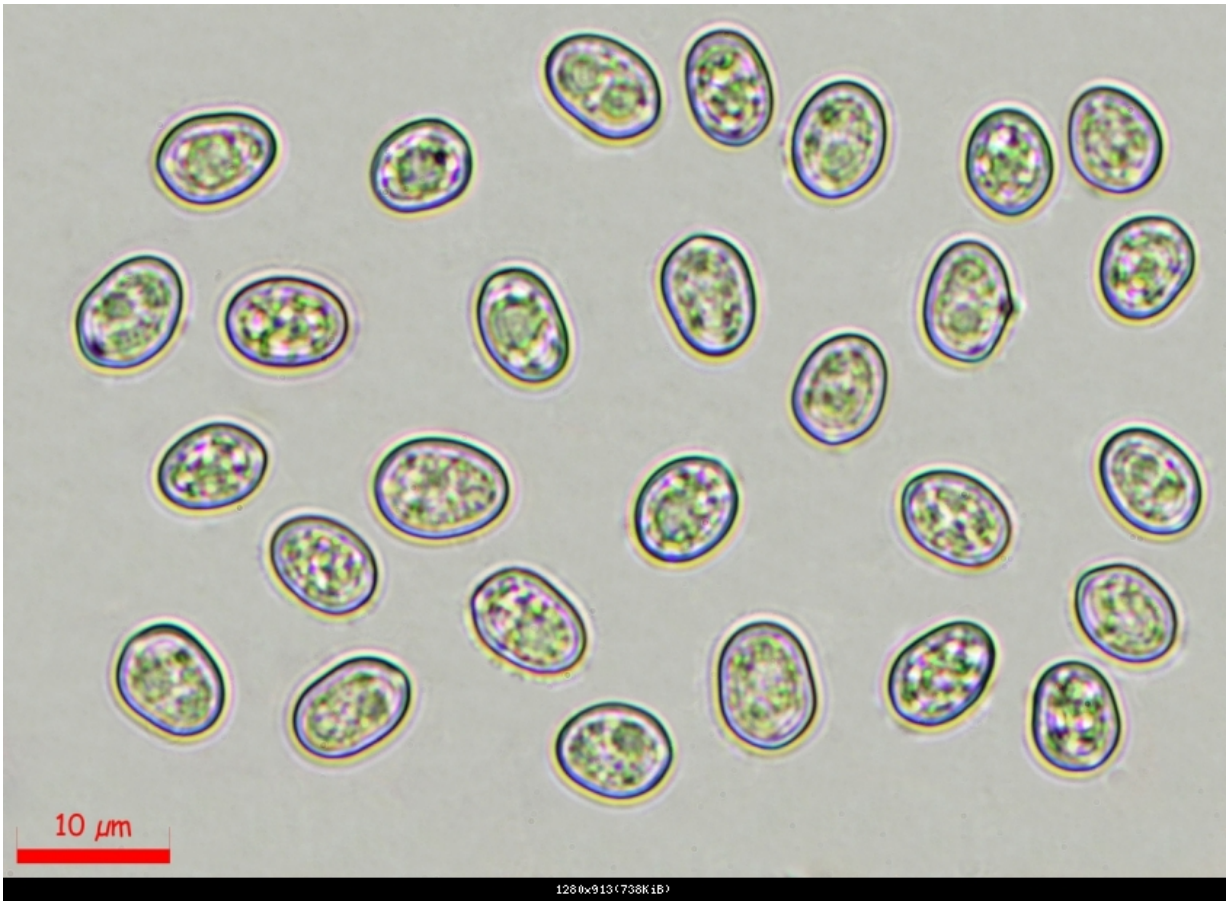


Above: A screen capture of Piximetre courtesy http://ach.log.free.fr/Piximetre/

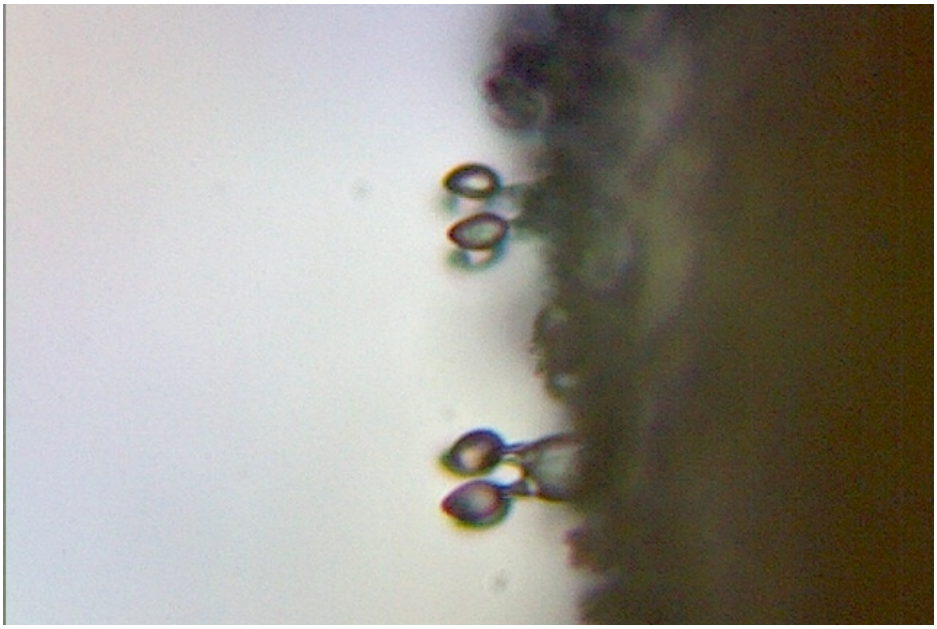
The site is in French and does not react to Google Translate but the program itself works in English once it's installed. If you can obtain the patience to email the makers, request an OS X version for Apple.

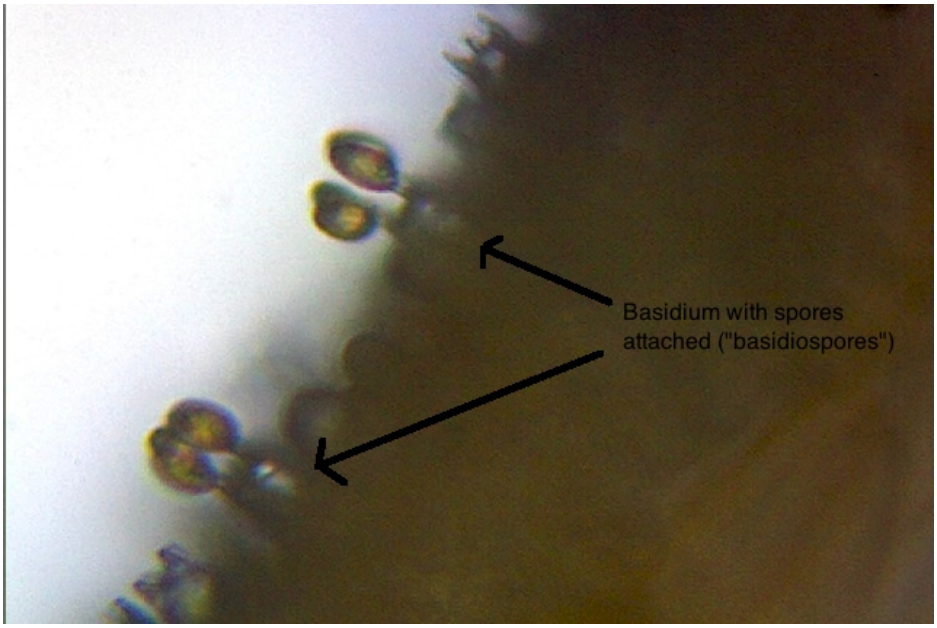
Recognizing Common Microscopic Cells/Structures

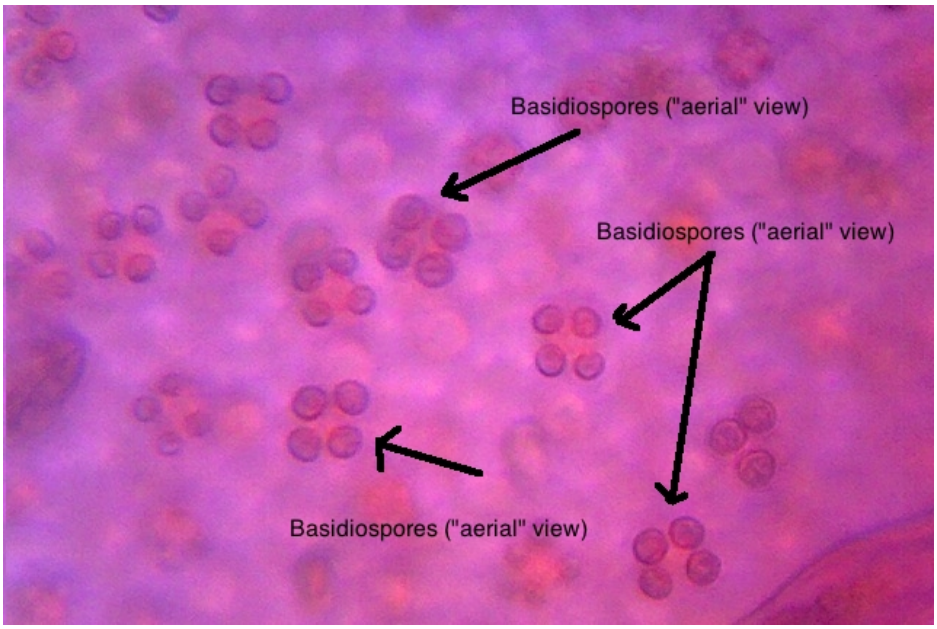
Below: Spores from the species *Pluteus cervinus*. Microphotograph by Alan Rockefeller.



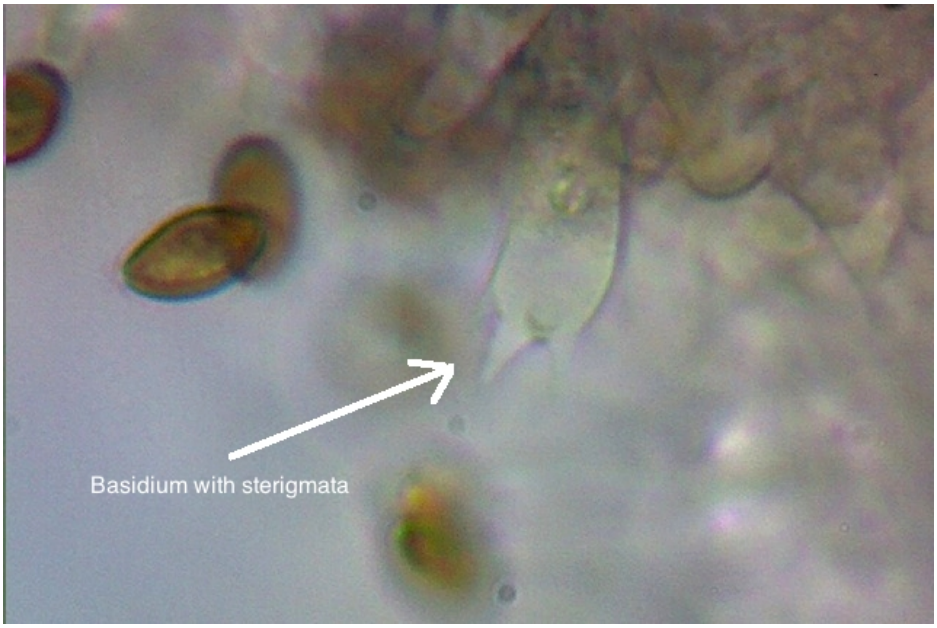
Below: Spores still attached to a basidium



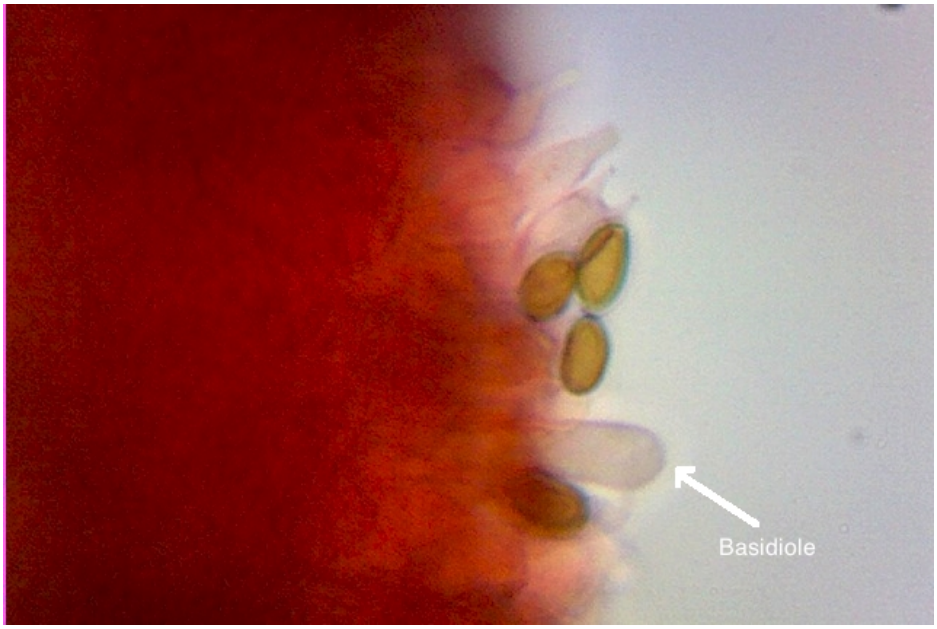




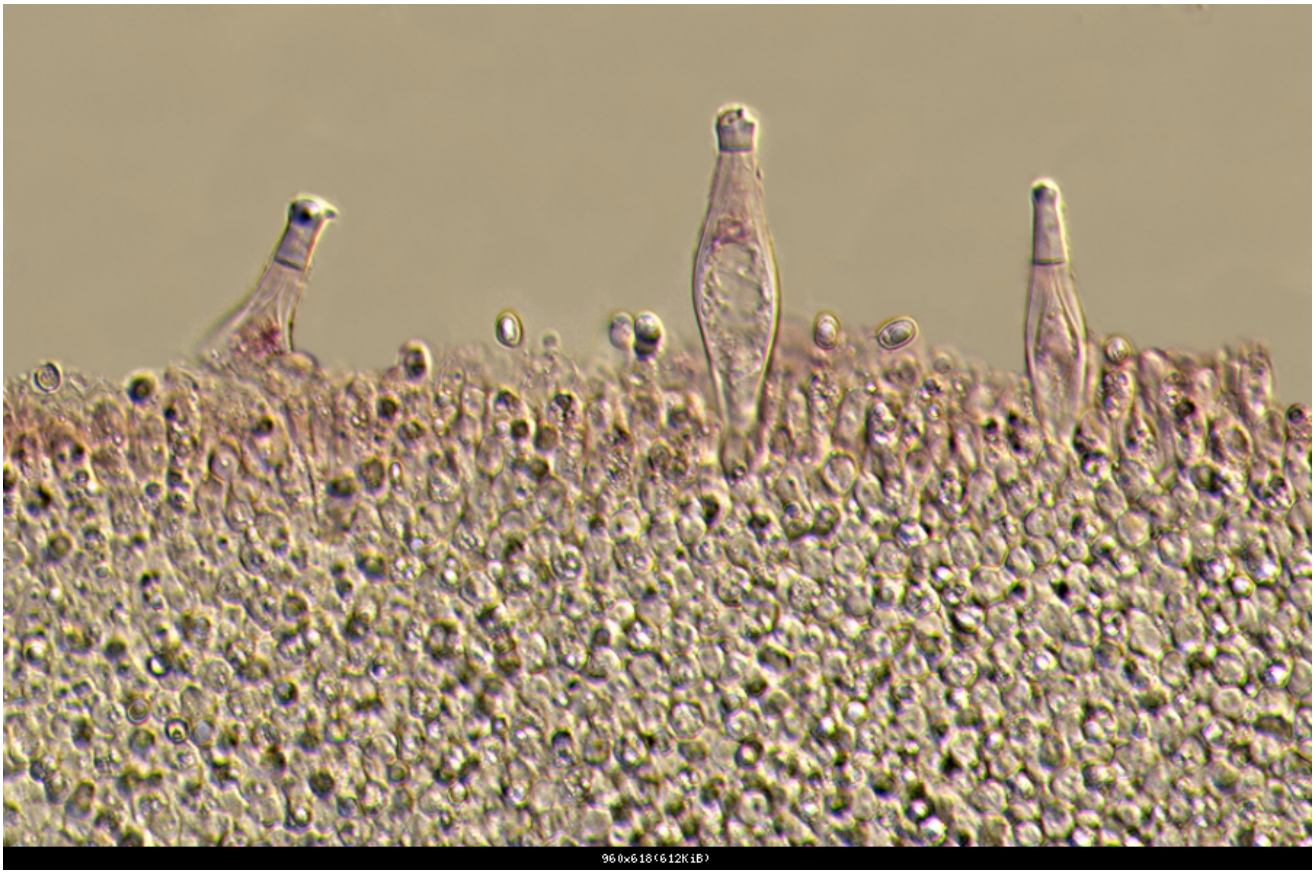
Below: Basidium (plural form = basidia)



Below: Basidioles (These look like basidia but lack sterigmata and spores)

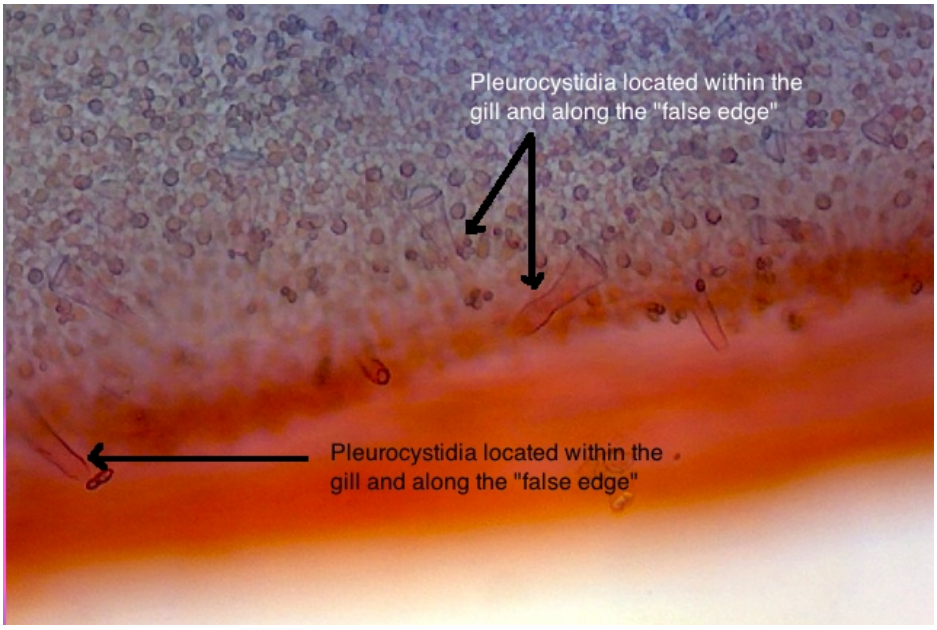


Below: Cheilocystidia from the species *Pluteus cervinus* courtesy Alan Rockefeller

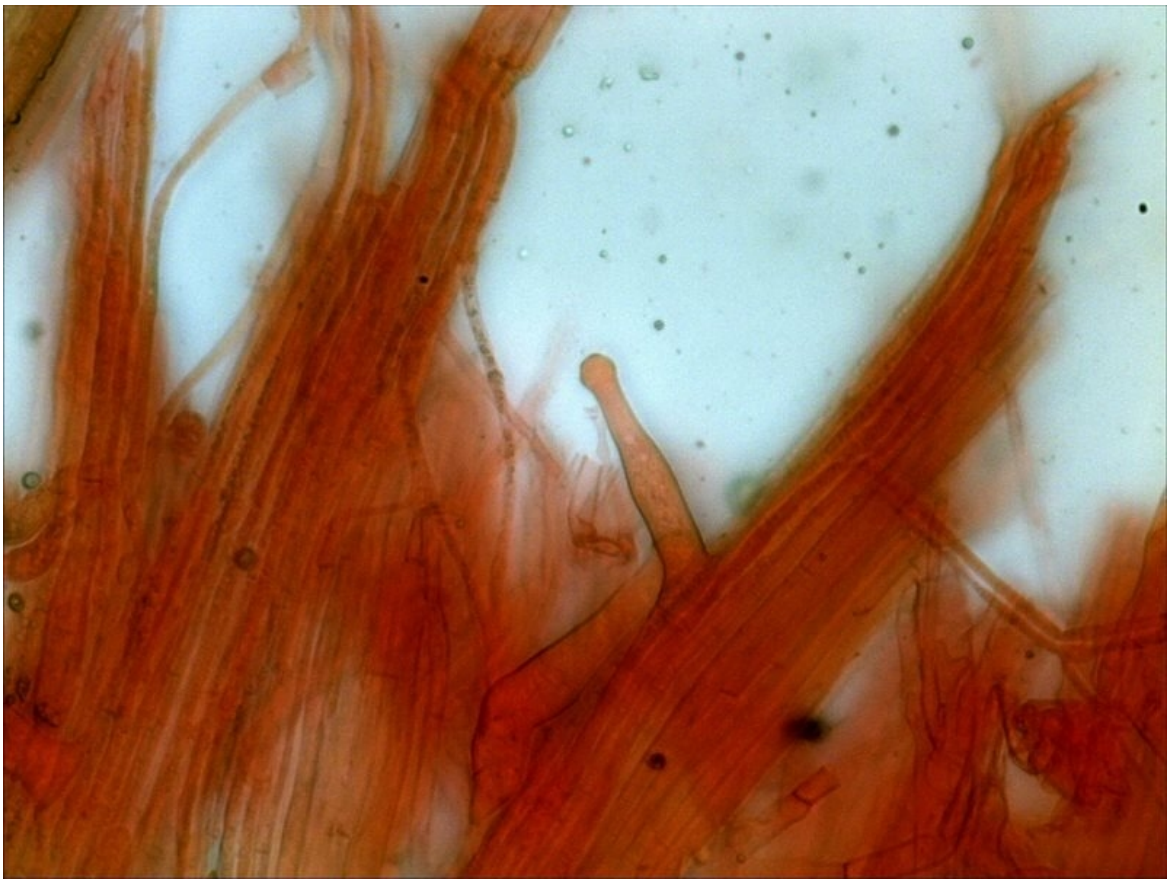


Below: A zoom of the two cheilocystidia cells from the same slide seen above (courtesy Alan Rockefeller)

Below: Pleurocystidia



Below: *Strobilurus stephanocystis* stipe cystidia (caulocystidia). Anton Soklič collection.



The four basic things you need to find with a microscope are: A. Spores B. Cheilocystidia, C. Pleurocystidia, and D. Basidia.

(Depending on the genus caulocystidia, pileocystidia, circumcystidia, and chrysocystidia are also important in identification. So is the the pattern of the pileipellis and the presence or absence of clamp connections in various parts of a mushroom's hyphae).

How To View & Measure Spores

Above: A microphotograph of *Asterophora lycoperdoides* spores at 1000x magnification (and with 4 stacked images) captured by Mycologist Alan Rockefeller

Spores are measured in microns using length then width. Measure the longest length of each spore and the widest width (this includes ornamentation). Measure with the 100x oil objective if you are not performing digital measurements. To obtain spores for measurement, take a spore print directly on a glass slide (or scrape some onto a slide), add a drop of soap water, add a cover slip, and it's ready for the microscope. You'll be measuring only mature spores. The ones in ***face view*** and ***side view*** are the ones you'll be measuring.

Preparing A Slide For The First Time

Below: A portion of a mushroom pileus is placed (gills down) on a microscope slide, resulting in this spore print (courtesy Nino Santamaria). A light spore print is all that's needed, sometimes produced within a very short period of time.

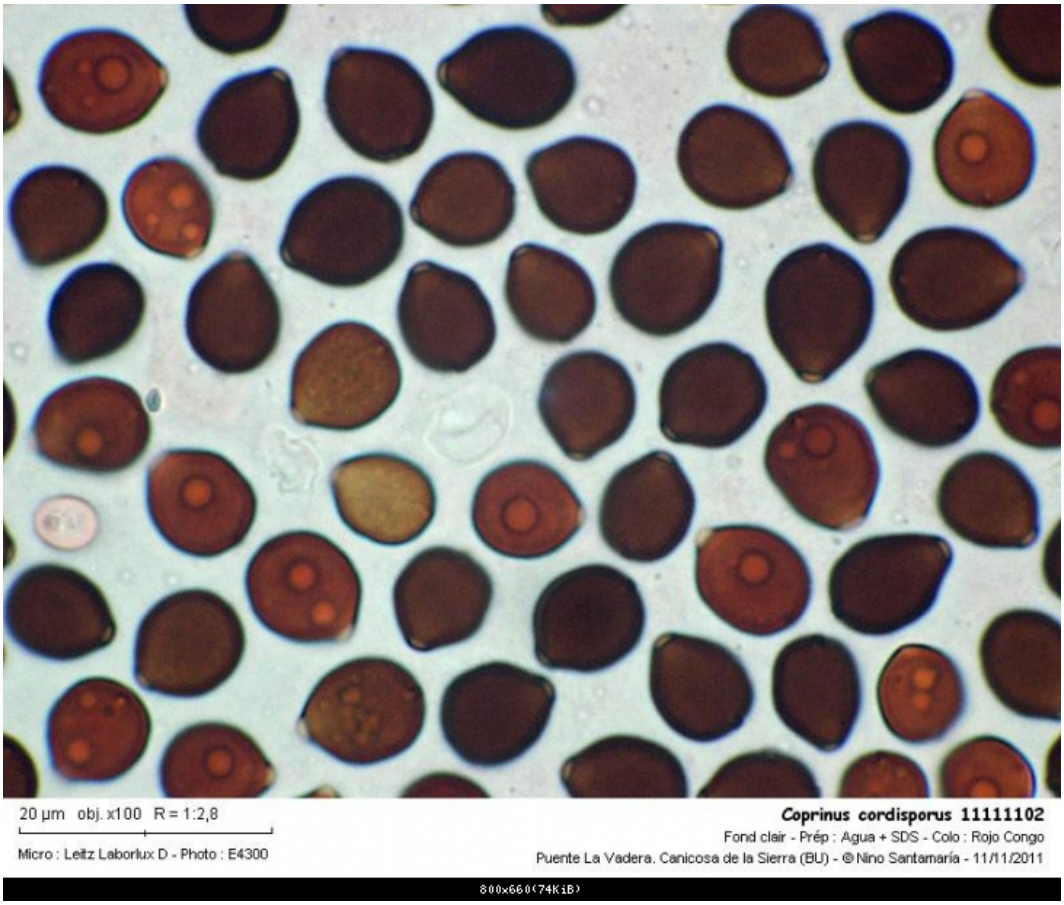
Below: A good percentage of spores are gently scraped onto a fresh slide into a precise area. One drop of H2O is added in the center.

xyz

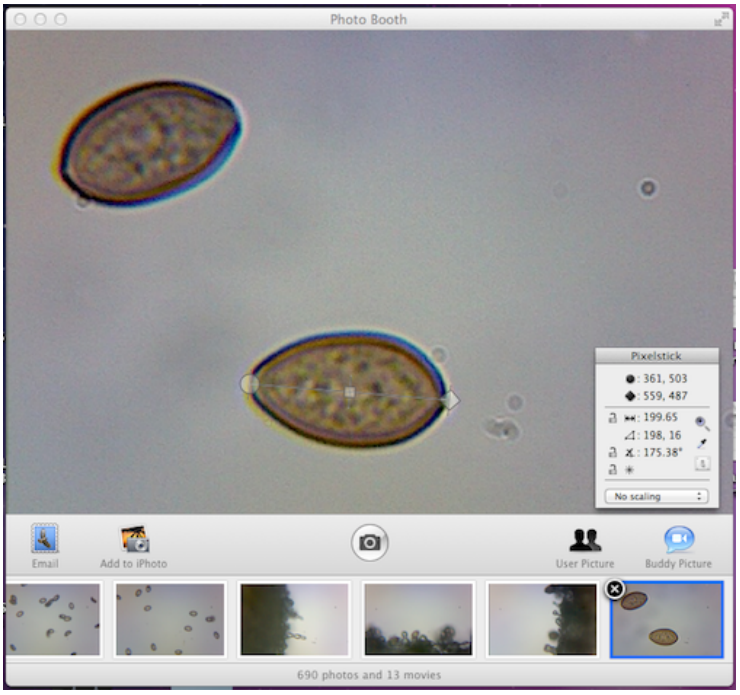
Below: A cover slip is placed on top of the drop, setting one side (=one edge) down first and slowly letting the other half rest on the slide.

xyz

Below: A good cluster of spores viewed at 1000x (*Coprinus cordisporus* courtesy Nino Santamaria).



Below: zzz



Below: Spores in face view (and therefore good for measurement)! *(Psilocybe pseudoaztecorum* courtesy Alonso Cortés-Pérez)

Below: Spores in side view (and therefore good for measurement)!

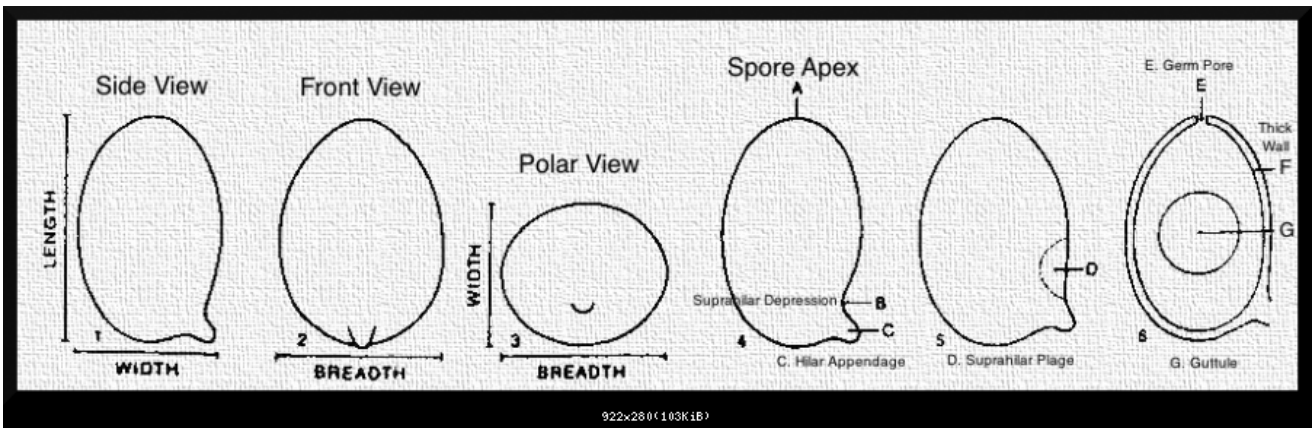
xyz

Below: Spores not in face view or side view and therefore not good for measuring!

xyz

Extra Notes For Measuring Spores

A thorough observation of spores will include the following: Size, shape, wall thickness, color, ornamentation, symmetry, attachment, and contents (oil droplets (guttules), etc).



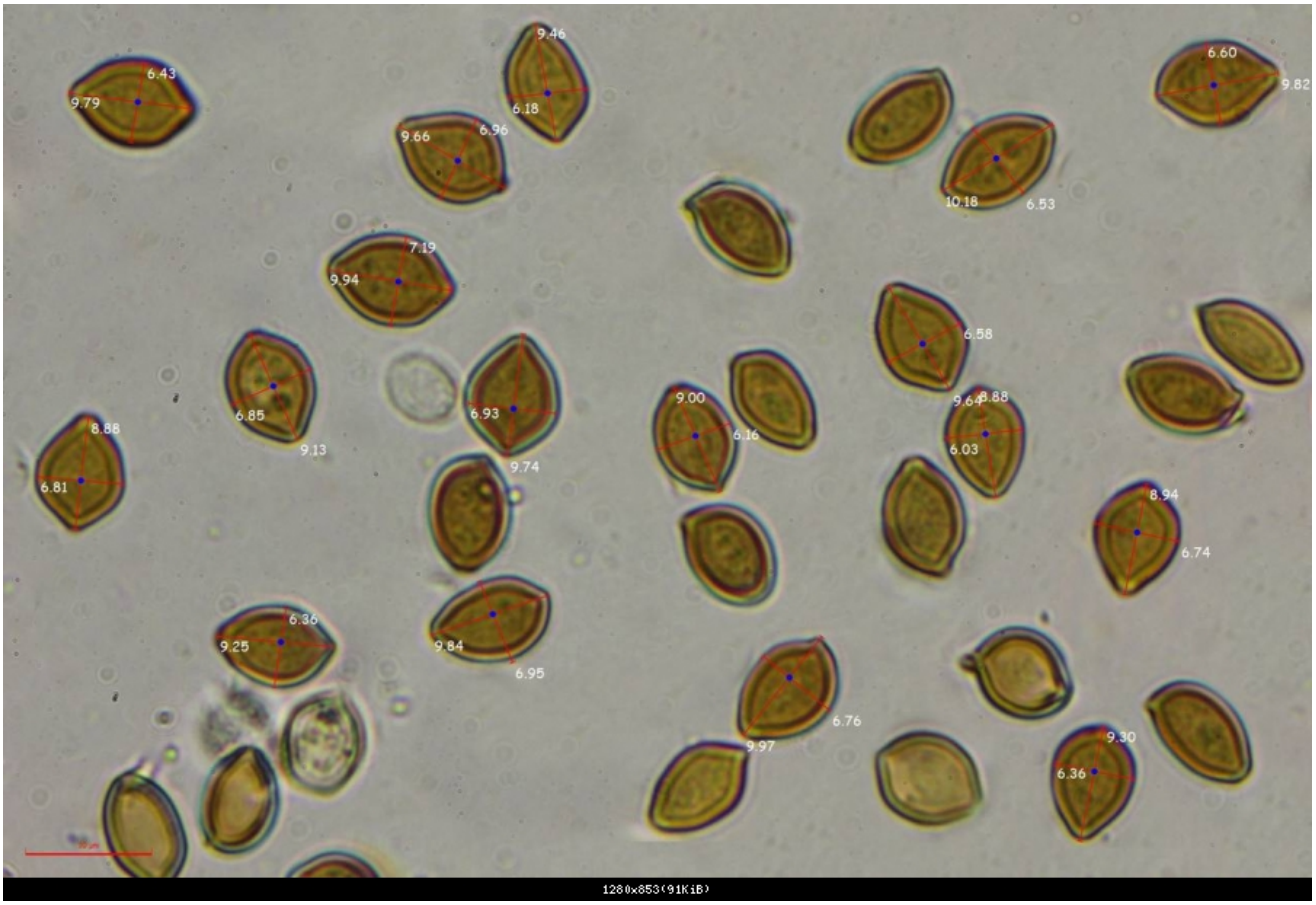
Above: Spore length, width, and breadth. Notice also the following terms: Suprahilar pendgae, suprahilar plage, hilar appendage, germ pore, and guttule.

Officially you need to measure 30 random, mature spores and drop the two highest and two lowest measurements. If you aren't doing an official description you can of course measure as many as you wish, but 10 would be normal. Measuring up to 50 or 55 spores would be a higher standard to hold to and is encouraged for increased accuracy and trust. Other statistics you should include (after dropping the 2 largest and smallest): The Q also called Quotient (total length average divided by total width average), the minimum length and width, the maximum length and width, and the average length and width.

Measurement of spores typically includes the ornamentation but not the apiculus. However, an exception to this rule exists. Spores which have very, very large ornamented surfaces (this is rare) are measured by taking two measurements: One of the ornamentation itself and another of the spore without the ornamentation. Please note this with your measurements. In addition to the requirements already mentioned, care should be taken not to include the hilar appendage with spore measurements.

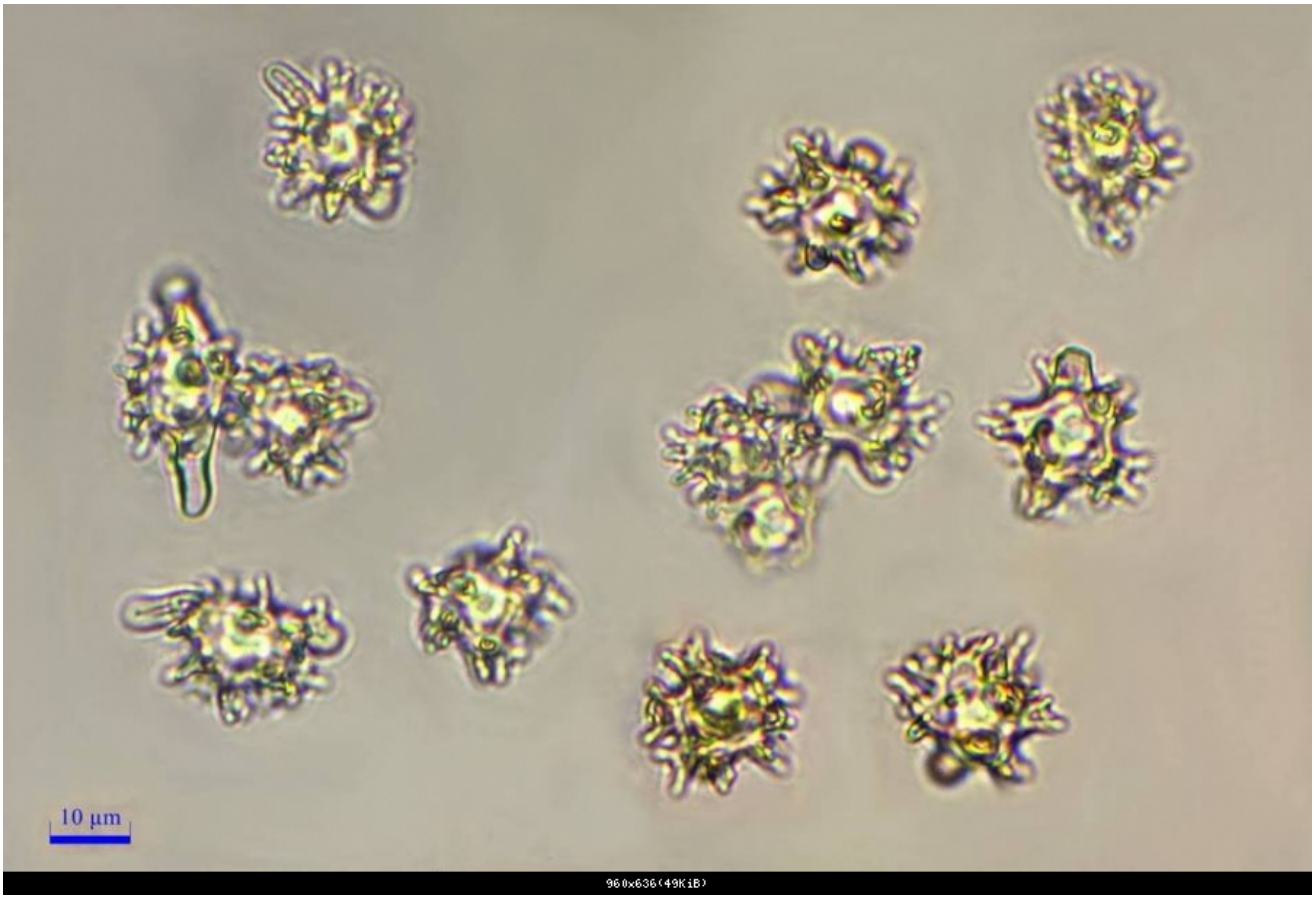
Final Tips: With your measurements, remember to include how you prepared your slides. If you can't get a spore print out of your mushroom, you may still be able to see spores by looking first on the pileipellis and stipe since those are guaranteed to be mature. If you still can't find spores this way make a gill cross section, press on the cover slip with a pencil eraser, gently crushing and stretching out the gill. Under the microscope, search through all of the tissues for spores, but remember that you may be viewing immature spores if you find them. If you can't find spores with this method, odds are high that your mushroom is simply immature, and has not yet developed spores. White-colored spores are usually better viewed when mounted in Melzer's Reagent or Dilute Lugol's Solution if Melzer's is unavailable. I prefer measuring spores from spore print rather than measuring them from gill tissue although both methods are currently accepted.

Below: Spores digitally measured (*Psilocybe subaeruginascens* courtesy Alan Rockefeller (MO #128946)



The Basic Microstructures Of A Spore

Below: *Asterophora lycoperdoides* spores at 400x (Microphotograph by Alan Rockefeller)



Below: Microstructure One (Cell Wall Thickness). The spore cell wall thickness is a valuable observation. Here is a comparison between a thin wall, a "normal" wall, and a thick wall.

xyz

Below: Microscructure Two (Ornamentation). A comparison of five common spore ornamentations. The ornamention (if an ornamentation is present) is also valuable in descriptions of spore appearance.

xyz

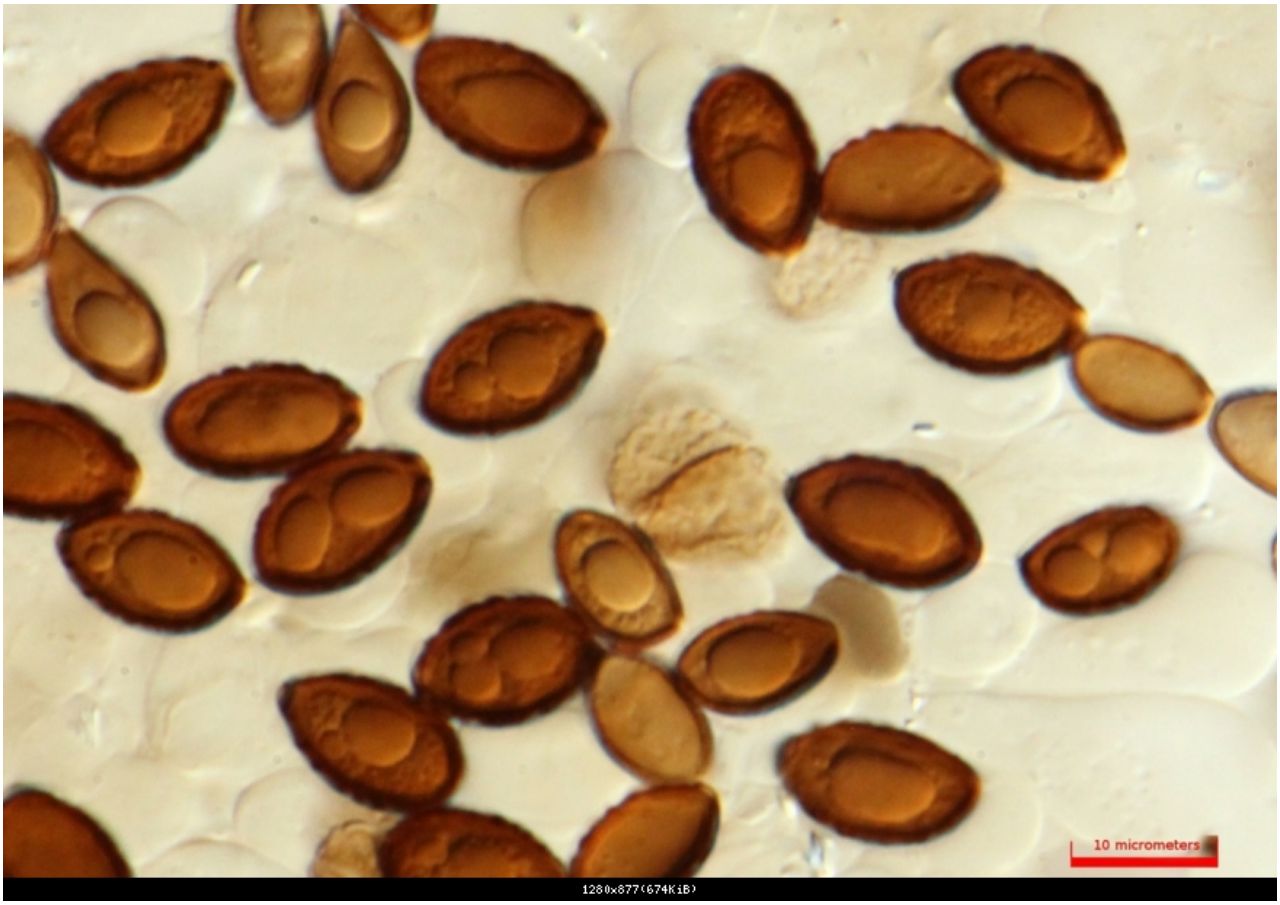
Below: Microstructure Three (Germ Pore). Germ pore width comparisons ranging from absent germ pore to wide germ pore

xyz

Below: Microstructure Four (Hilar Appendage). Note that difference between the germ pore and the hilar appendage (where the spore was connected to the tip of a basidium)

xyz

Below: Microstructure FIve (Guttules). Some spores (sometimes in low percentages among different species) will have one or two oil drops (guttules). *Panaeolina foenesecii* spore microscopy courtesy Alan Rockefeller.



Below: Microstructure Six (Symmetry). Spore symmetry should also be noted. Here are several common spore symmetries for comparison.

xyz

Below: (Suprahilar Impression). A comparison between a hilar appendage, a suprahilar depression, and a suprahilar plage

xyz

Spore Microcharacters of Value

Size (Length and width in microns)
Germ pore width
Shape of spores
Wall thickness
Spore color (*)
Ornamentation
The presence or absence of a germ pore
Symmetry
Attachment
The presence or absences of a membrane (perispore)
Pigmentation Reaction
The presence or absence of oil drops
Spore karyology
Hilar appendage

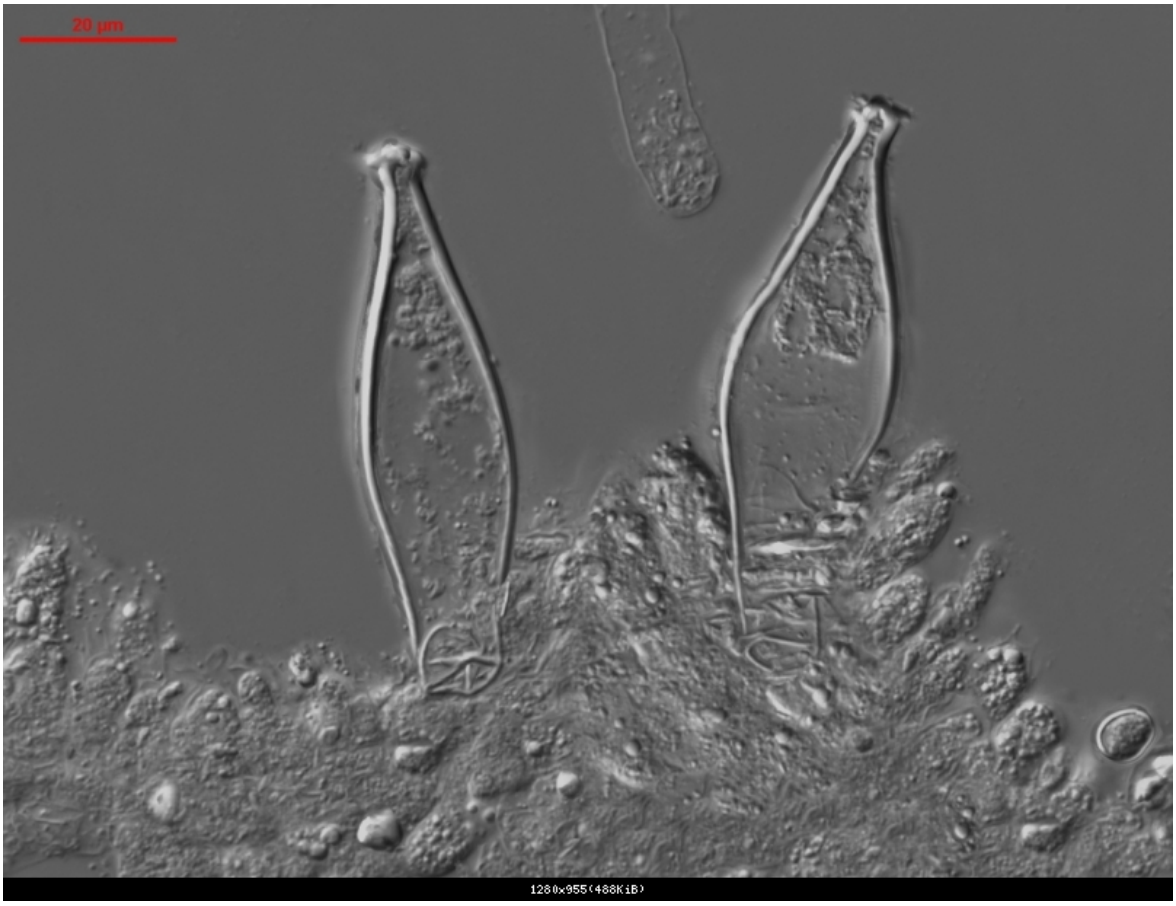
*A spore print's color does not necessarily reveal the color of individual spores. Also, spores can change color depending on the mounting liquid(s) and stains selected, and if they are piled ontop of one another.

Before and After: Spore Color Reactions with Melzer's, Cresyl Blue, Sulphuric Acid (=Sulfuric Acid), KOH, & Other Liquids

xyz

How To View & Measure Cheilocystidia

Below: A microphotograph of cheilocystidia from *Pluteus cervinus* (courtesy Mycologist Alan Rockefeller)



Below: This image has been zoomed in to approximately 4,000x. A single cystidia cell is measure by its longest length and widest width using Macnification.

There are two standard methods worth knowing for viewing cheilocystidia.

Below: Two slides, the higher one is a "preparate cut-out" and the lower is a "gill cross section."

Method 1: Preparate Cut-Out: Removing A Single Gill & Sectioning A Specific Area

Below: Remove a single gill from anywhere in the mushroom using a .009 blade, then cut out a section in the center as seen below. This section will have the cap on top, pleurocystidia within the gill and along the side "false edges," and cheilocystidia on the bottom "true edge."

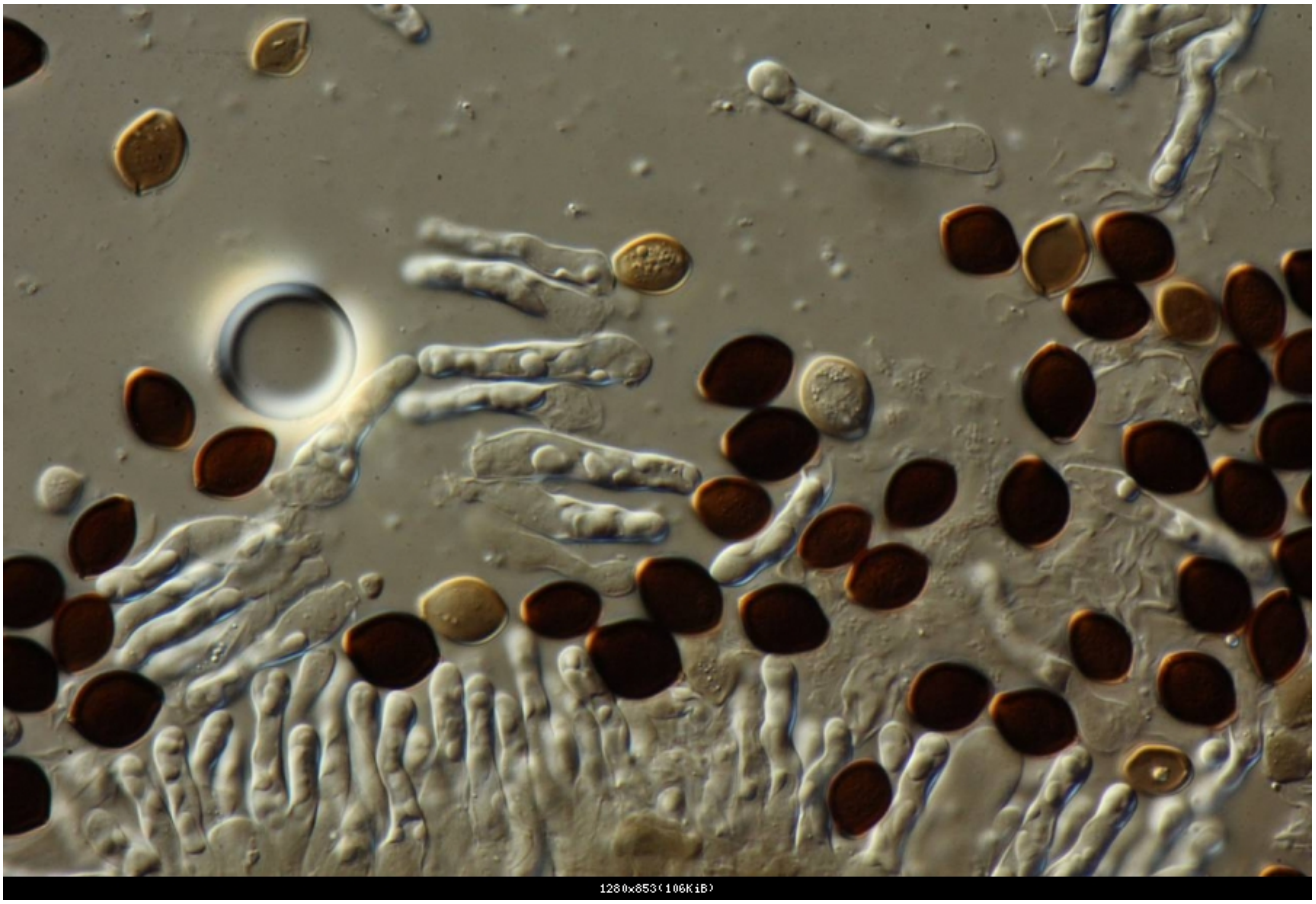
xyz

xyz

Prepare your sections on a separate, new piece of paper before transferring the material to a microscope slide.

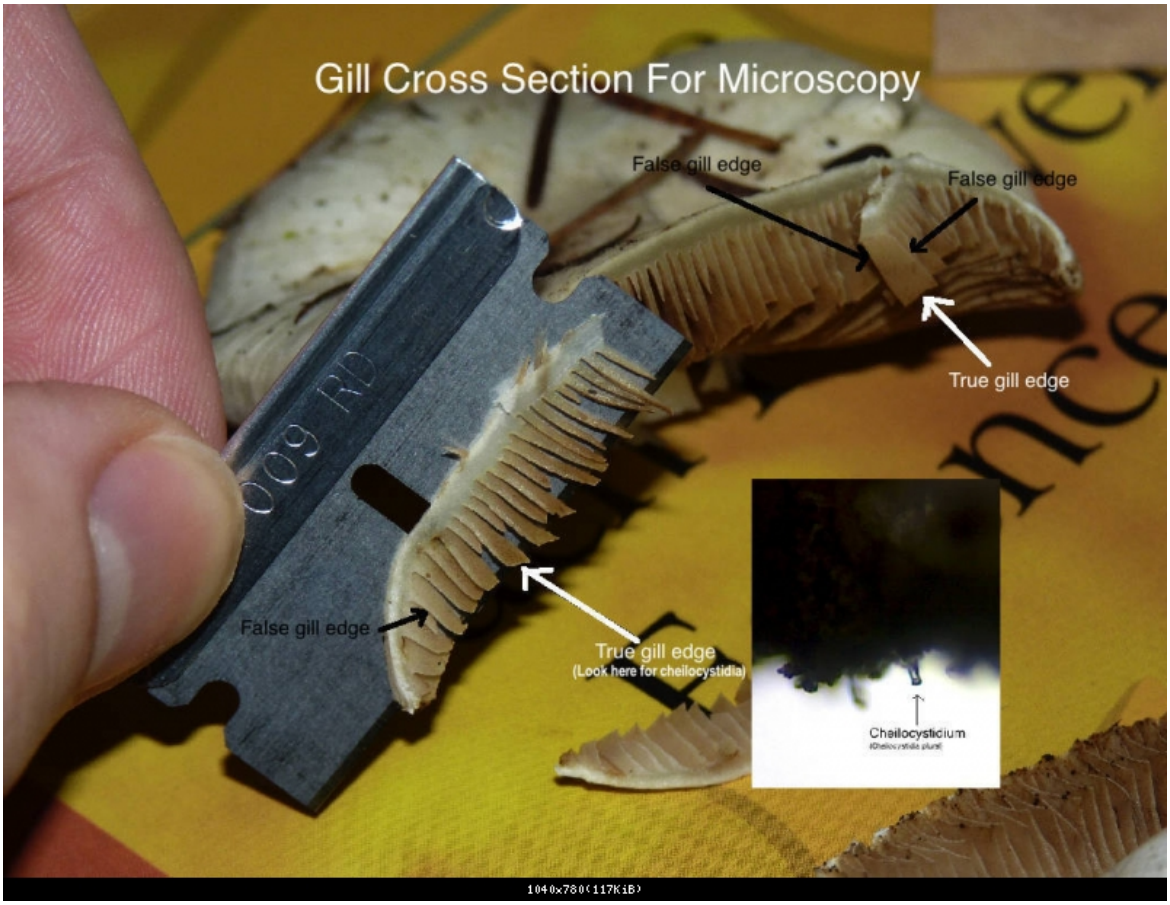
Note: It may be difficult to see the base of the cheilocystidia. Do the best you can and scope around for the best looking, most clear ones. Measure from the base to the tip for the length (looking for the longest measurement in each individual cheilocystidium, then measure the widest width). If visibility is a slight issue you may approximate (but tell others that this had to be done in your notes). There will usually be multiple shapes of cheilocystidia for each species. You'll want to display these types to give as accurate of a description as possible.

Below: *Panaeolus acuminatus* cheilocystidia cells along the true gill edge and separated by performing a crush mount (courtesy Alan Rockefeller)



Tip: If there are too many spores in the way to view the cheilocystidia try this: Using the edge of a napkin, soak up the liquid (and spores). Then remount in a liquid. This is sometimes necessary to perform with 3% KOH two or even three times to get a crisp view of the cystidia.

Method 2: Creating A Gill Cross Section To View Cheilocystidia

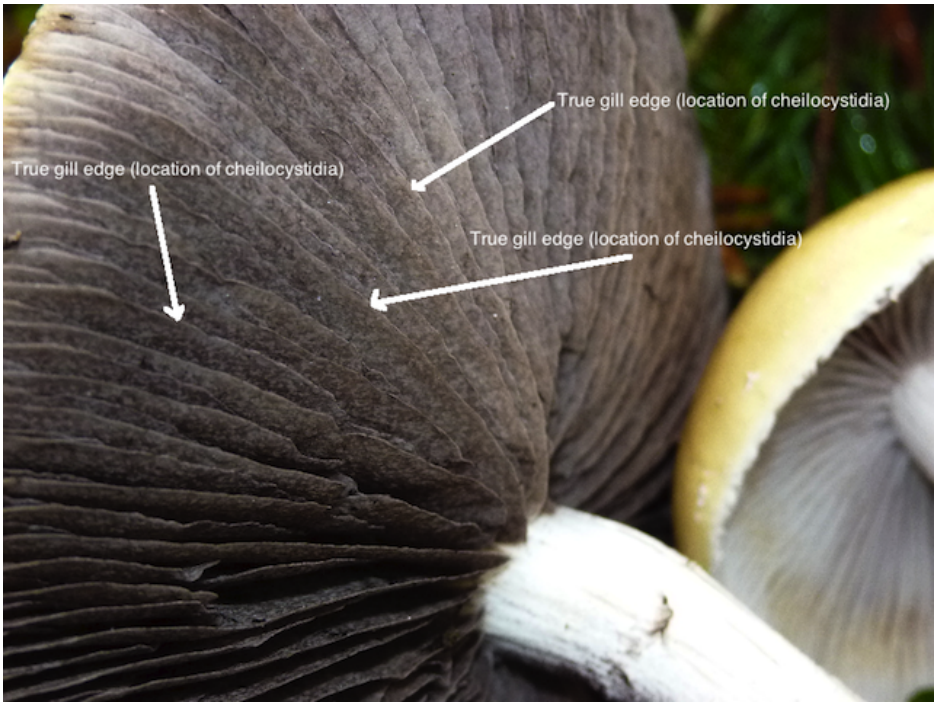


*Using a freshly harvested mushroom (or recently harvested mushroom), remove the stem from the cap, then place the cap gills-down.
*Make a a section and discard it. This will allow you access to a perfectly straight area with closer access to the gills.
*Make your actual gill cross section - a very, very thin (almost impossibly thin) section.
*Ideally, you like it to be a lengthy section but if you're new to this or working with small or fragile mushrooms, aim for a section with around five gills in it.
*Cut your slice on a very slight angle, so one side is too thick and the other side gradually becomes thinner until perfectly thin. Cut off any parts that are not quite thin.
*Place the thin section, even if it's just a few gills wide, in the center of a slide and add a stain such as congo red for roughly 1-2 minutes. Soak up the excess stain with the edge of a napkin.
*Now add drops of either 3% KOH or distilled water, wait a couple of minutes, and then cover with a cover slip. The KOH or water solution needs to be under the full area of the cover slip.
The slide is now ready for the microscope.

Below: A gill cross section at a distance (*Agaricus bisporus*). Look along the tips of each gill for cheilocystidia.

Note: Always use proper caution when working with KOH, congo red, and other liquids. Review the content label or online description in advance of use.

Below: A field image of a Stropharia species (closeup of the gills)



It may be difficult to see the base area of many cheilocystidia which could inhibit perfect measurements. If this prevents accurate measurements you can perform a crush mount (ie squash mount). Instruction are listed below. As with all other measurements, utilize the 100x oil objective whenever possible. Measure 30 cheilocystidia. Drop the two highest and two lowest measurements and work out the average length and width and the quotient (q). Take your width measurements at the widest part of the cystidia, also measure the length and width of the neck if they are unusually long or wide/thin.

Tip: There are usually multiple shapes of cheilocystidia for a species. It's best to photograph/illustrate the most representative types, instead of just one cheilocystidium form.

Advanced Method For Viewing & Measuring Cheilocystidia

It may become helpful to remove as much material that could not contain cheilocystidia as possible. To do this, create a *preparate cut-out* as instructed above. If it's already fresh and hydrated - great. If not, rehydrate it in 3% KOH. Now take either a needle (or even a razor blade) and make an incision along the border where cheilocystidia would no longer be seen. This will require guess-work but with some experience the incision area should be under 1mm from the true gill edge.

The new section will become a more specific area to view cheilocystidia, but even better - go ahead and do a *crush mount*. First stain it in congo red, soak up the excess liquid, "wash" it by placing one drop of distilled water on it and soak up the excess liquid. Mount in 3% KOH and add a cover slip. Using a pencil's eraser, gently press down on the cover slip where the cheilocystidia cells are. Attempt to break them free from each other without harming them. Now you should be able to see the entire cheilocystidia cells and make some fantastic measurements!

Note: It helps to cover your finger with a kimwipe/tissue/paper towel and press down semi-hard on the cover slip. The squash forces extra water out from under the cover slip and can sometimes rise onto the cover slip. Avoid Kleenex and bathroom tissue for this procedure because it will leave paper fragments on the glass.

Below: A cheilocystidium in its entirety thanks to a crush mount

Below: A preparate cut-out is seen on a slide in KOH. An incision is made to include only the cheilocystidia. The aim for this incision is approximately .5mm from the true gill edge.

xyz

Note: Some mushrooms will reveal forked cheilocystidia usually alongside unforked cheilocystidia. These

should also be included and not confused with basidia. Measure from the base of the cystidia to the longest tip to obtain the length measurement.

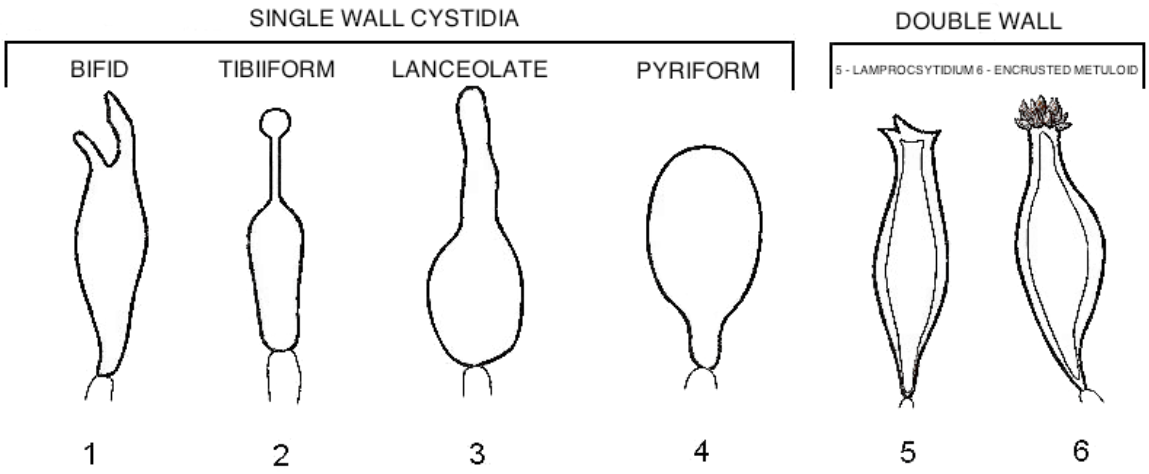
Below: A forked cheilocystidium next to a unforked one.

xyz

Below: Additionally, there are some species which produce branching cheilocystidia (they have multiple branches)

xyz

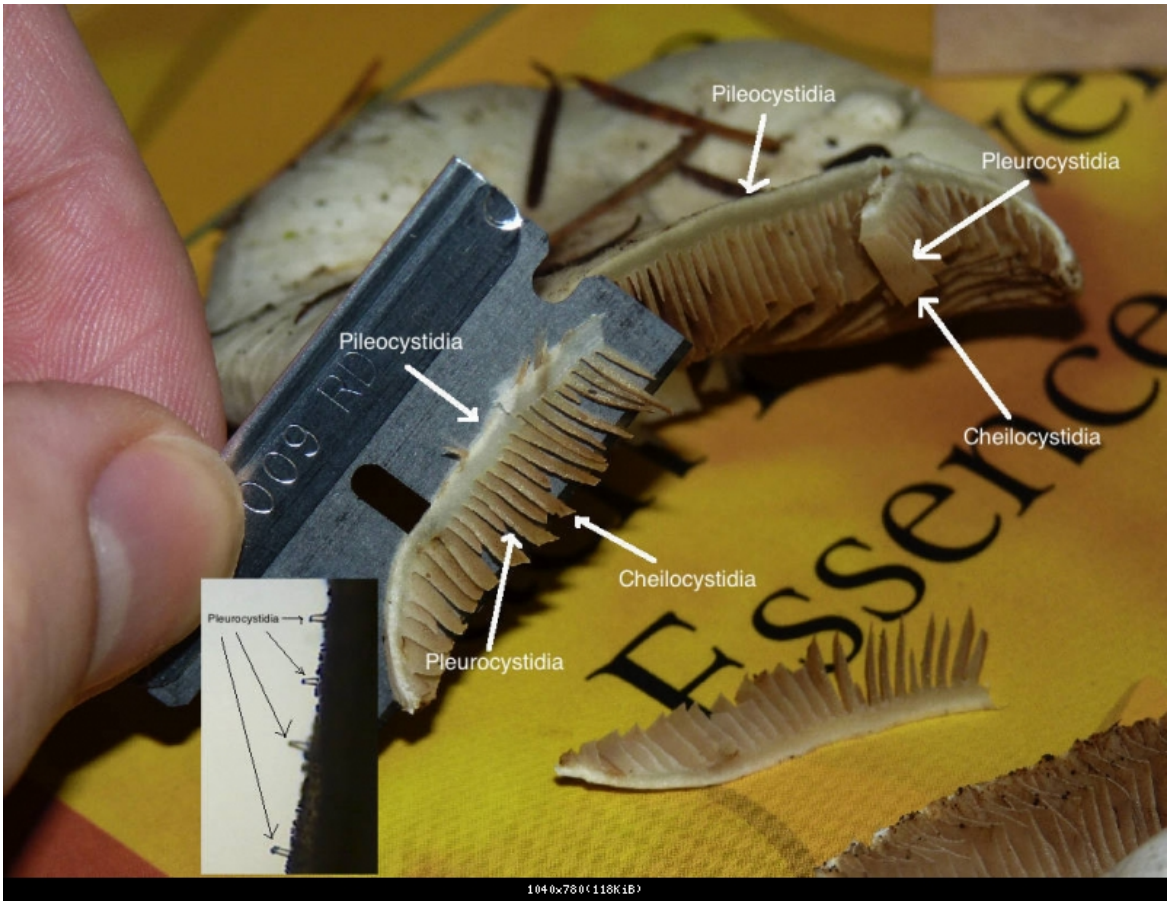
Below: A quick guide to a few common types of cystidia (both cheilocystidia and pleurocystidia forms)



How To View & Measure Pleurocystidia

Pleurocystidia are located within the gill (not on the true gill edge) and can be viewed throughout the gill face. Not all species develop pleurocystidia.

Below: A gill cross section with arrows showing where to look for different cystidia types



There are technically two titles/locations for pleurocystidia:

1. Pleurocystida located within gill (viewable along the "false edges" and throughout the gill)

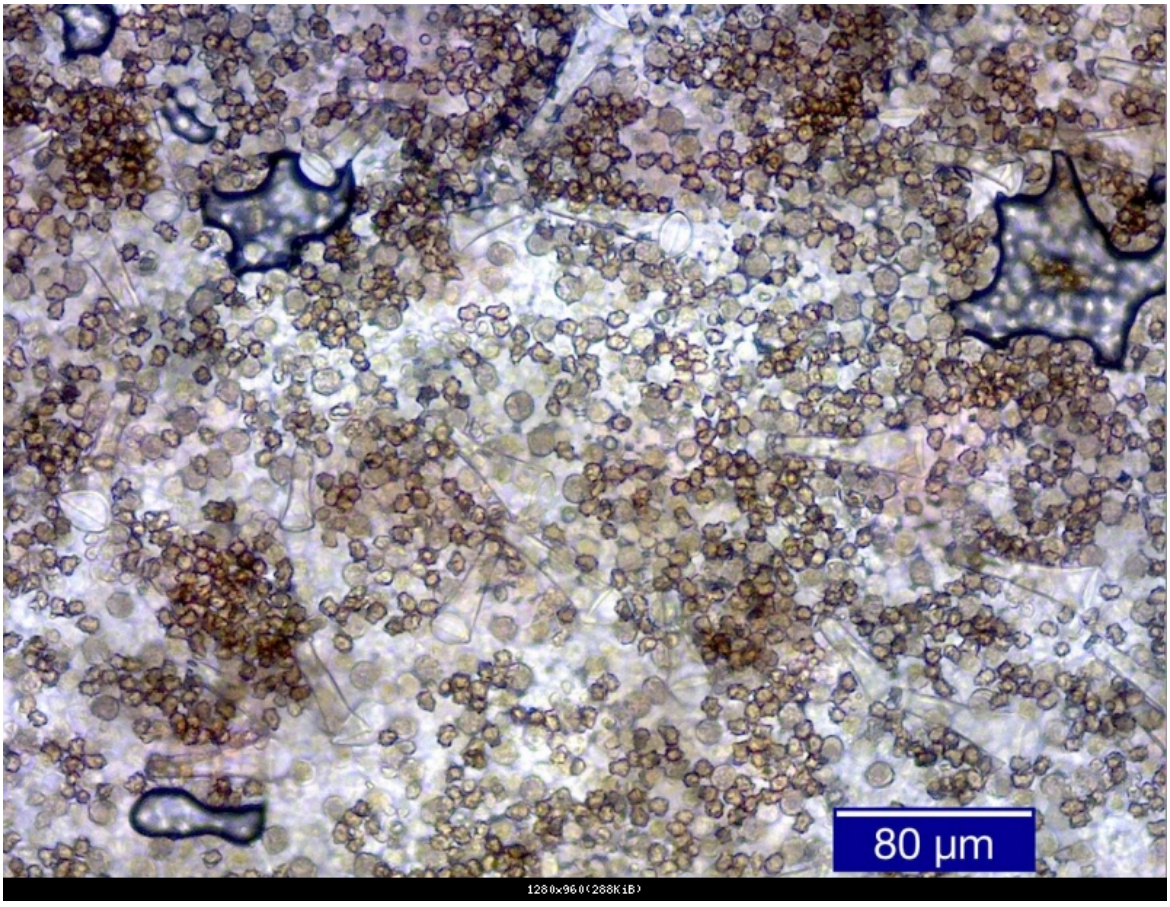
2. "Pleurocystidia near the true gill edge" (very near to the cheilocystidia)

Don't worry about pleurocystidia "near" the gill edge for now - some mycologist will still call it cheilocystidia because of its close location to the gill edge cheilocystidia area. You can use either the method pictured in this document (ie a preparate cut-out or a gill cross section), but I'd advise you to embrace both methods. Make sure the pleurocystidia, if visible, is a good distance from the cheilocystidia (about 1mm away / 1000 microns). Keep in mind that a gill cross section is cutting through material in the opposing, unnatural direction - whereas a preparate cut-out removes a section of a gill in its natural form.

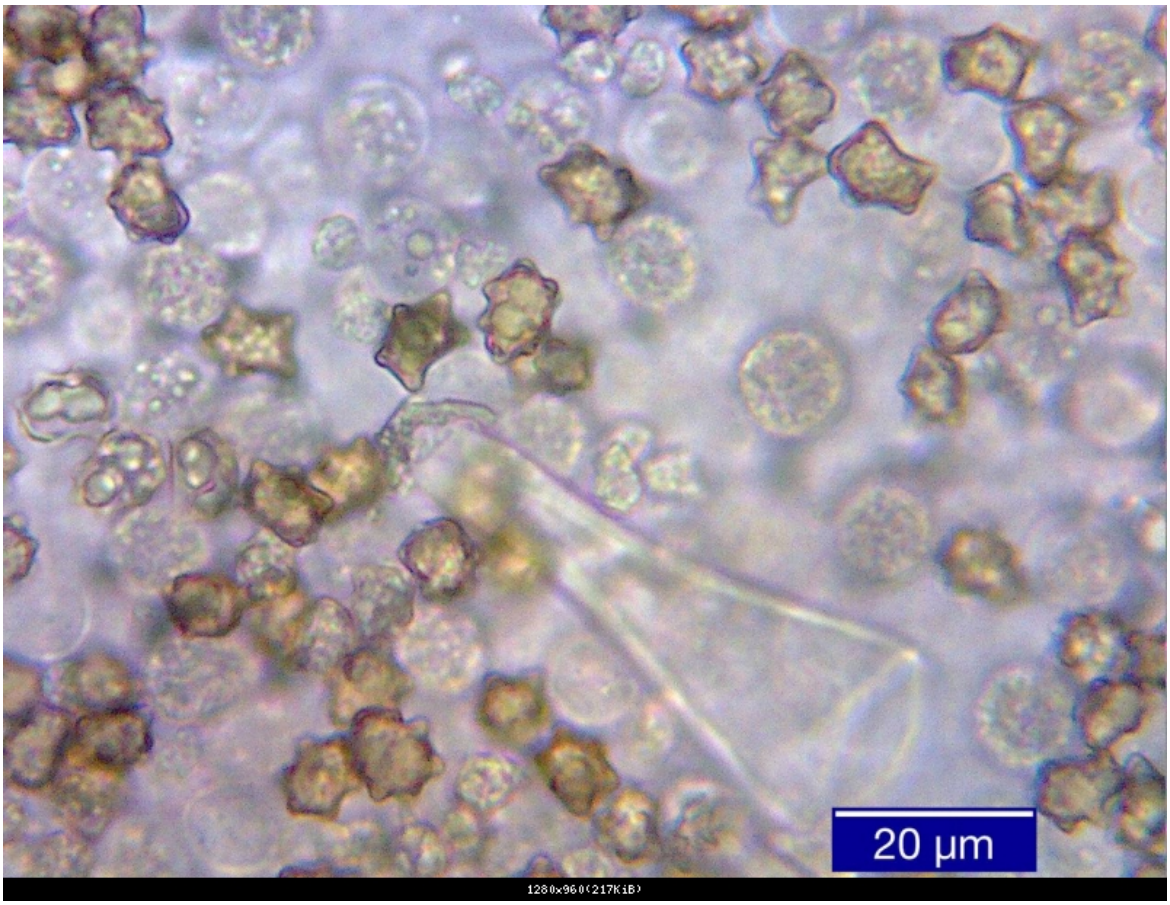
Below: A *preparate cut-out*. In this particular instance, the gills of this large mushroom were too big to include the pileus in the section. Normally, it would.

Pleurocystidia can be found along the "false gill edges" of a *preparate cut-out*. Pleurocystidia can also be found throughout the gill (as long as they're a good distance from the cheilocystidia).

Below: Pleurocystidia in good quantity within the gill



Below: A pleurocystidium up close (within the gill)



When using a *gill cross section* pleurocystidia can be found along the sides of the gill teeth (while the tips would reveal only cheilocystidia).

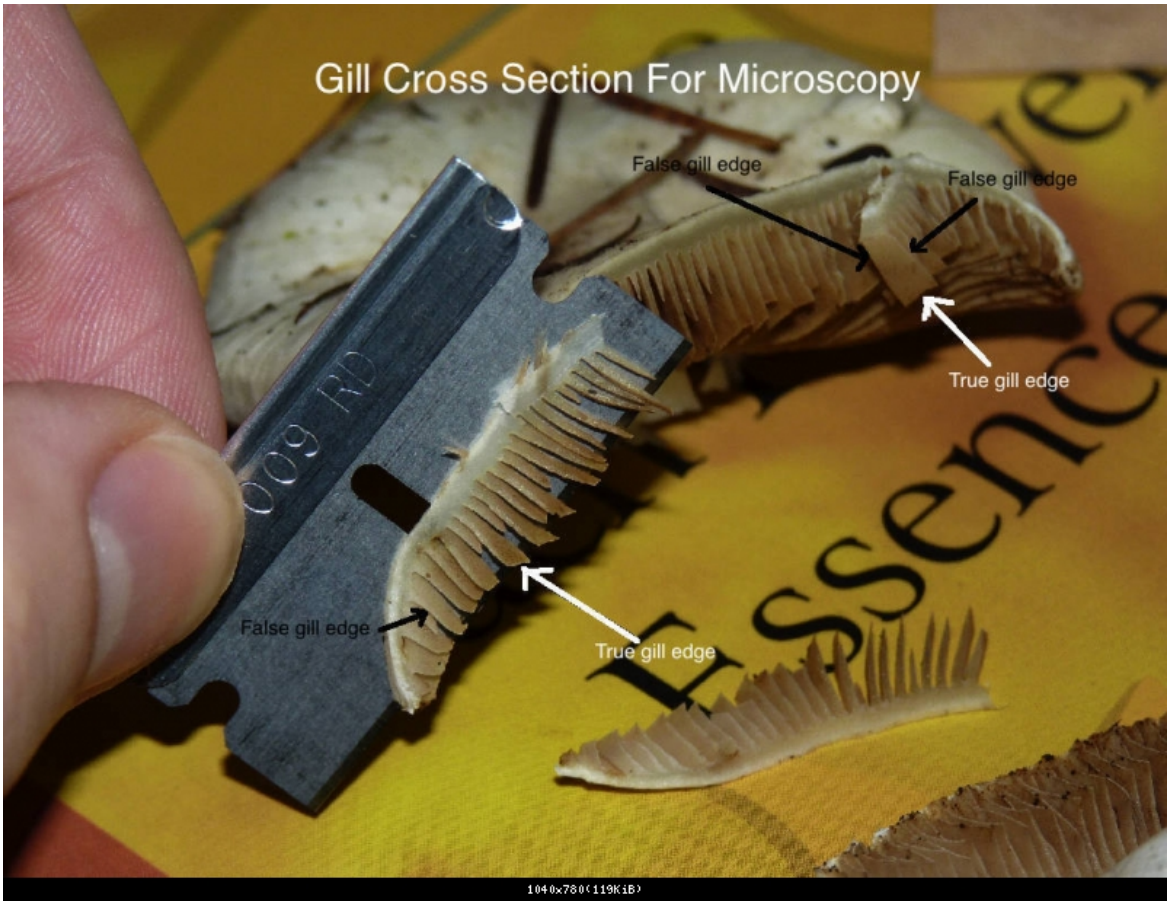
Below: A gill cross section at a distance. Look along the sides of each gill and see if you can locate any pleurocystidia.

xyz

As is the case with basidia and cheilocystidia, it may be difficult to see the base of many pleurocystidia. Do your best with measurements and find only those pleurocystidia which are worthy of measurement. Remember to tell others how you prepared your slide(s). Some mushrooms do not have pleurocystidia, and in some instances the pleurocystidia may simply not be viewable on one or more sections. If this occurs the best thing to do is simply note, "no pleurocystidia observed."

Tip: On many occasions there will be multiple shapes of pleurocystidia for a species. It's best to photograph/illustrate the most representative types so the observation is as complete as possible.

Below: It's important to remember where the "true gill edge" is located so you can distinguish between cheilocystidia and pleurocystidia (pleurocystidia is located along the "false gill edges").



Measure 30 pleurocystidia and drop the two highest and two lowest measurements. Work out the average length and width, as well as the quotient. Take your length measurement based on the longest length and width measurements at the widest part of the cystidia. Note: Some cystidia have unusually wide, thin, or long necks. In this event, also measure the length and width of the neck and note this in addition to the normal cystidia measurements.

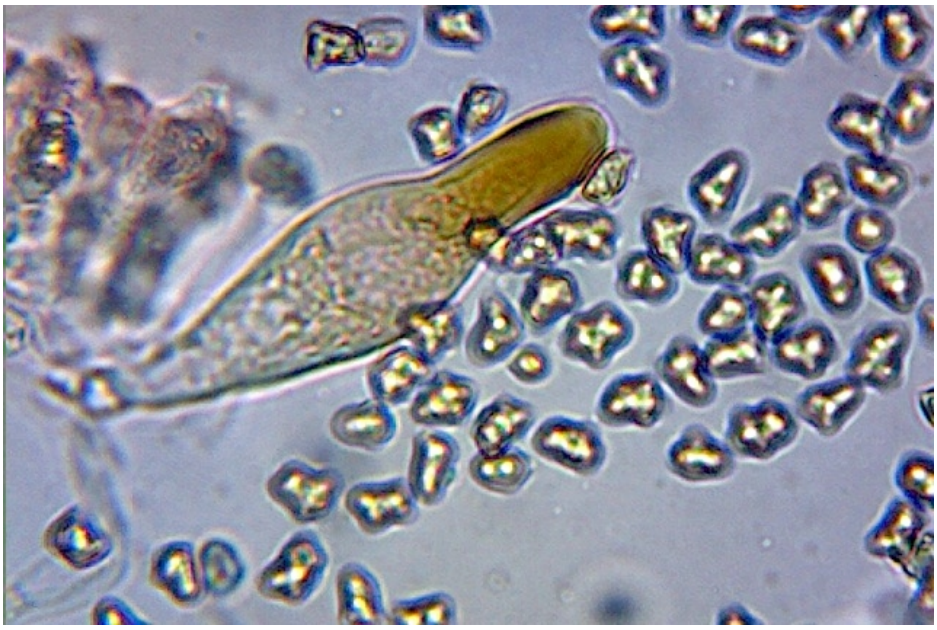
Advanced Method For Viewing & Measuring Pleurocystidia

It may become helpful to remove any material that could contain cheilocystidia. To do this, create a *preparate cut-out* as instructed above. If it's already fresh and hydrated - great. If not, rehydrate it in 3% KOH. Now take either a needle (or even a .009 blade) and make an incision along the border where cheilocystidia can no longer be seen. This will require guess-work but with some experience the incision area should be over 1mm from the true gill edge. Discard the gill edge section.

The new section will become a more specific area to view pleurocystidia, but even better - go ahead and do a crush mount. First stain it in congo red, soak up the excess liquid, "wash" it by placing one drop of distilled water on it and soak up the excess liquid. Mount in 3% KOH and add a cover slip. Using a pencil's eraser, gently press down on the cover slip. Attempt to break several pleurocystidia free without harming them. Now you should be able to see more clearly pleurocystidia cells. Note: It helps to cover your finger with a kimwipe/tissue/paper towel and press down semi-hard on the cover slip. The squash forces extra water out from under the cover slip and can sometimes rise onto the cover slip.

You can use this same section of the gill for observing and measuring basidia.

Below: A pleurocystidium freed from the gill thanks to a crush mount



What If I View Pleurocystidia & Yet Other Mycologists Have Described The Same Species & Concluded It Is Not Present?

Remember there are two basic methods in this document for viewing pleurocystidia - a *gill cross section* and a *preparate cut-out* - plus a third, advanced method. When discrepancies occur use all three methods and use multiple gills from multiple mushrooms. Check using fresh fungi, freshly harvested. Compare to dried/rehydrated material a few days later. Take micrographs. Anomalies in description are possible. Multiple collections from different locations will help. If you view fresh mushrooms under the scope (as opposed to rehydrated, dry samples) you may see more pleurocystidia. Regardless, observations should be noted along with micrographs for comparison (ie microscopy performed on freshly harvested mushrooms).

How To View & Measure Basidia

Basidia should be discerned from *basidioles* (which lack sterigmata and do not produce spores). They can be found at times along the true gill edge and far more abundantly along the “false gill edges” (the incision lines of a cut out section). Measure from the base of the basidium to the tip of the tallest sterigma (but don’t include the length of spores).

Note: When describing the mushroom’s microscopic features also mention how many sterigma are seen on the basidium. Typically it will be four.

Measure only mature basidium. See images below for comparison between developing basidia and a fully developed one.

Measure 30 fully developed basidia and work out the average length and width and the quotient after dropping the two highest and lowest numbers.

Important Basidia Microcharacters

Number of sterigma
Overall shape(s) (Morphology)
Length and width measurements (typically in fully developed basidia)
Wall thickness
Development and attachment from originating hyphae (including basal clamp connections)
Growth stages
Presence or absence of oily or granular contents
Reaction to chemicals (stains, KOH, etc)
The presence or absence of carminiferous granules in basidia (method: mount your section in aceto-carmine--whatever that is--heat it over a flame, and zzz)
zzz

Below: A comparison of two-sterigma, three-sterigma, four-sterigma, six-sterigma, and eight-sterigma basidia from different species

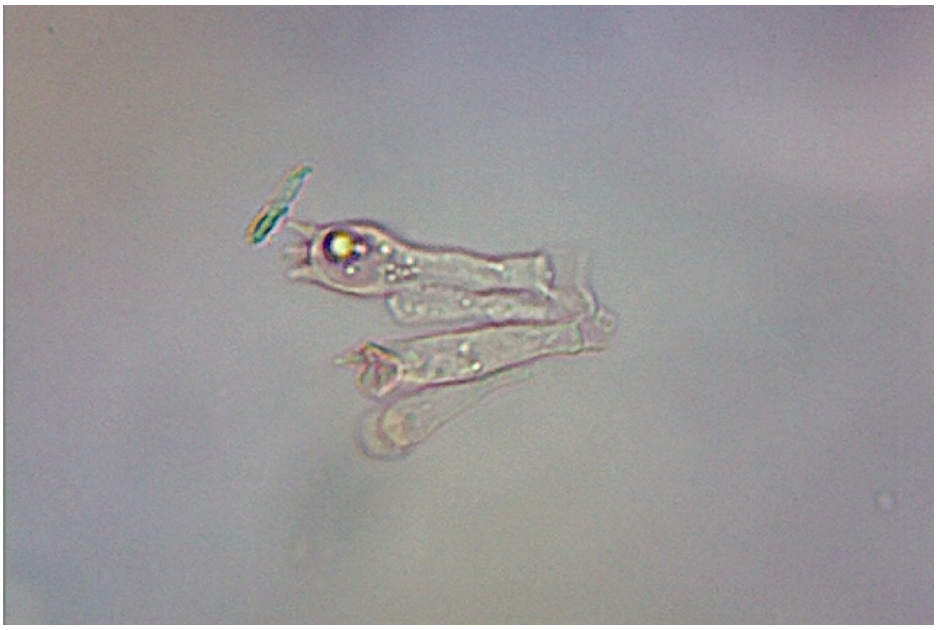
xyz

Advanced Method For Viewing & Measuring Basidia

Basidia are usually abundant throughout the gill. They can be difficult to see in their entirety, making measurements somewhat challenging. A crush mount will provide a much better method to see and measure. Here's how to do it: Take a single gill or a section of a gill (mounted with cover slip) and, using a pencil with an eraser, gently press down with the eraser head. This will break up the various cells in the gill, including several basidia. Have patience! It requires just the right amount of force. Too much and the cells are destroyed. Not enough and the cells won't separate from one another.

Note: It helps to cover your finger with a kimwipe/tissue/paper towel and press down semi-hard on the cover slip. The squash forces extra water out from under the cover slip and can sometimes rise onto the cover slip.

Below: A crush mount reveals a basidium (top-center)



Types of Basidia

To date, there is only one general type of basidium form described for gilled mushrooms: Holobasidia (though this can be compared to other types of basidia for non-Agaricoid fungi). Holobasidia (Synonymous with Homobasidia) are single cells basically clavate in form, with sterigmata that are fairly small in proportion to the basidium.

Growth Stages of Basidia

xyz

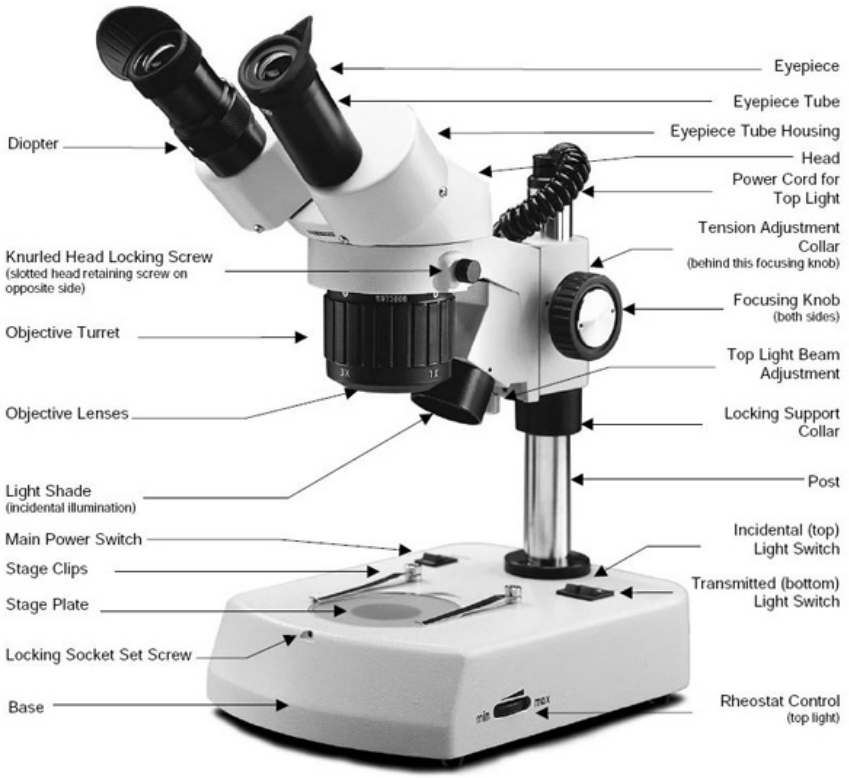
Working With Blurry Microstructures: Introducing The Water Bath & The KOH Bath

Some sections will be more visible by giving them a “bath” (a fairly quick submersion into either distilled water or 3% KOH). A separate container or piece of gear is not necessary. This bath is useful when a mushroom section is oily or too rich in spore deposits. It is also useful if you’ve stained the specimen too darkly with congo red.

After staining in congo red and soaking up the excess liquid with the edge of a napkin, simply add one drop of distilled water for many seconds and again soak this excess liquid from the specimen using a napkin. Mount in 3% KOH.

Alternatively, you’ll notice that some Amanita species respond better to one or two (maybe even three) 3% KOH water baths (instead of using distilled water).

Working with Small Specimens: Methods & Materials



Above: A stereoscope can sometimes be employed to view and work with smaller specimens

Many collections will consist of not only a limited amount of specimens, but very small specimens which require precision. Although sections can be made using standard, plain-sight methods, the use of a stereoscope may be useful. Simply place the fungal material onto the stereoscope slide, use low magnification, and allow the increased magnification to better guide your sections.

Below: A stereoscope with extremely small, dried fungal material resting on the stage material before being sectioned. Remember to clean the stage before and after thoroughly.

xyz

While both a gill cross section and a preparate cut-out are possibilities with small, dried mushroom, it will likely be far easier to methodically isolate a whole, single gill. Once a single gill is separated it may be possible to make a cut-out section to include the true gill edge, the gill face, the false gill edges, and the pileus layers.

Receiving Dried Collections & Performing Microscopy

Microscopic identification should, whenever possible, be performed along with macroscopic (normal vision) identification. For the person receiving a dried specimen or collection, it is of great importance to have quality photographs of the collection in peak condition to refer to. Microscopic features alone may not be sufficient to identify a mushroom to species, and quite possibly not even to genus.

In the event you choose to perform microscopy on a dried collection of mushrooms or small amount of dried material, effort should first be made to acquire mature, ejected spores from the surfaces of the stipe and pileus. Usually there will be a large population of spores on the annulus, veil portions, or upper portion of the stem. To obtain these spores, take a microscope slide and make contact with the upper portion of the stipe (or one the pileus surface). This will make an almost instantaneous yet light spore print. If none are acquired the mycologist will have to rely on mature spores within (from) a sectioned, rehydrated gill.

Instead of performing a gill cross section to view cystidia and basidia (& pileus layers and trama), a whole gill should be selected and made into a preparate cut-out. It can be hydrated in 5-10% KOH and then stained with congo red or another stain of your choosing (GSM, etc). If KOH is not available 70% isopropanol alcohol can be used in its place, followed by water.

Rehydrating A Single Gill After It's Fully Or Partially Dried

Starting with a whole, dried mushroom: Break off the stem then break the cap in half so you have full access to the gills. Using a razor blade, slowly press in between two gills and break off a whole gill. Once placed onto a slide, 2-3 drops of 5% KOH are added. After two minutes or more the KOH should rehydrate the specimen. Once it is rehydrated you may now absorb the excess KOH with a napkin corner/edge. Now a prepare cut-out can be made just as you would with a freshly picked specimen. A little more KOH should be added, if necessary, before adding a cover slip so it seen throughout the entire cover slip area.

Note: If you want to stain the gill after rehydrating it with KOH, just absorb the excess KOH with a napkin

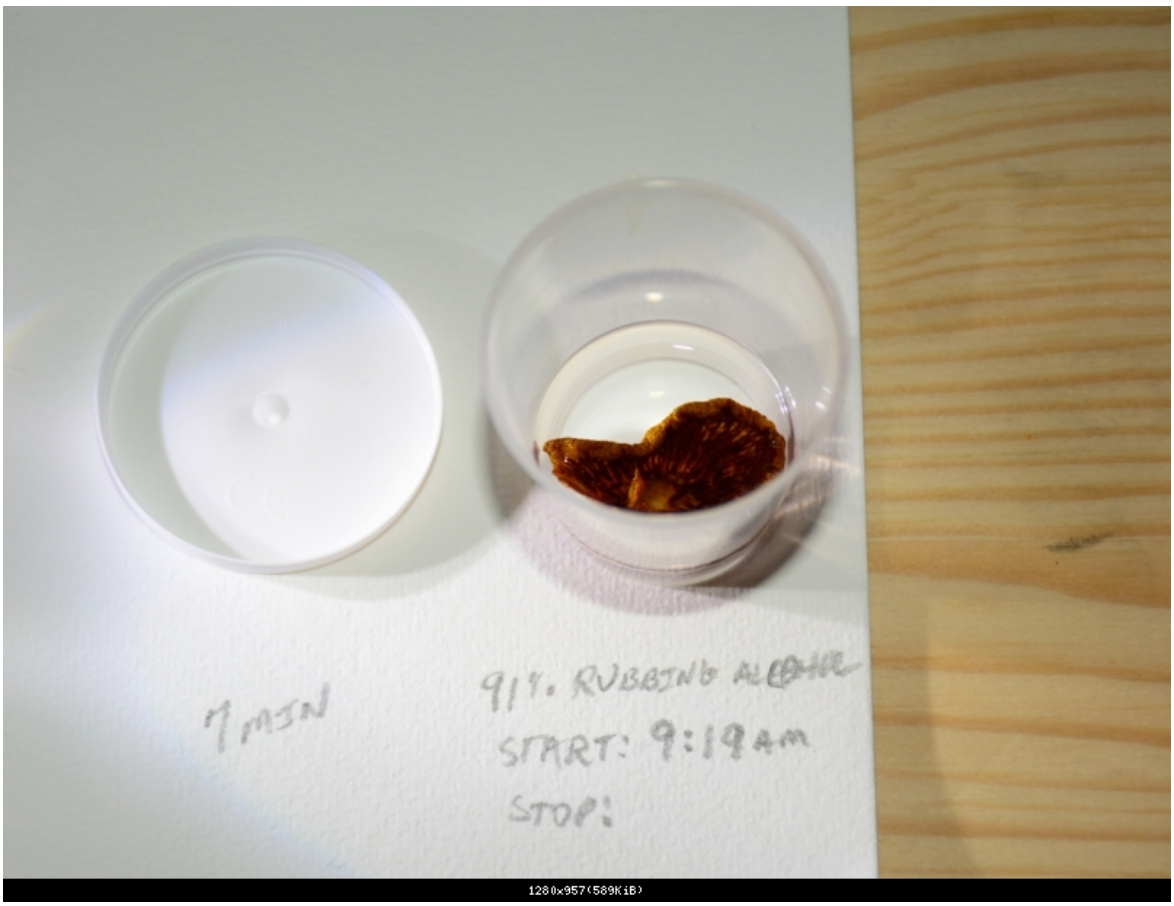
corner, then stain with congo red or another type of stain for a 1-2 minutes, absorb the excess congo red (or stain), then add more KOH and a cover slip.

Other liquids used for rehydration that are recommended: Ethyl alcohol (95% or 96%), isopropanol alcohol (91%), GSM, Abel's Fluid, and Clémençon's Solution.

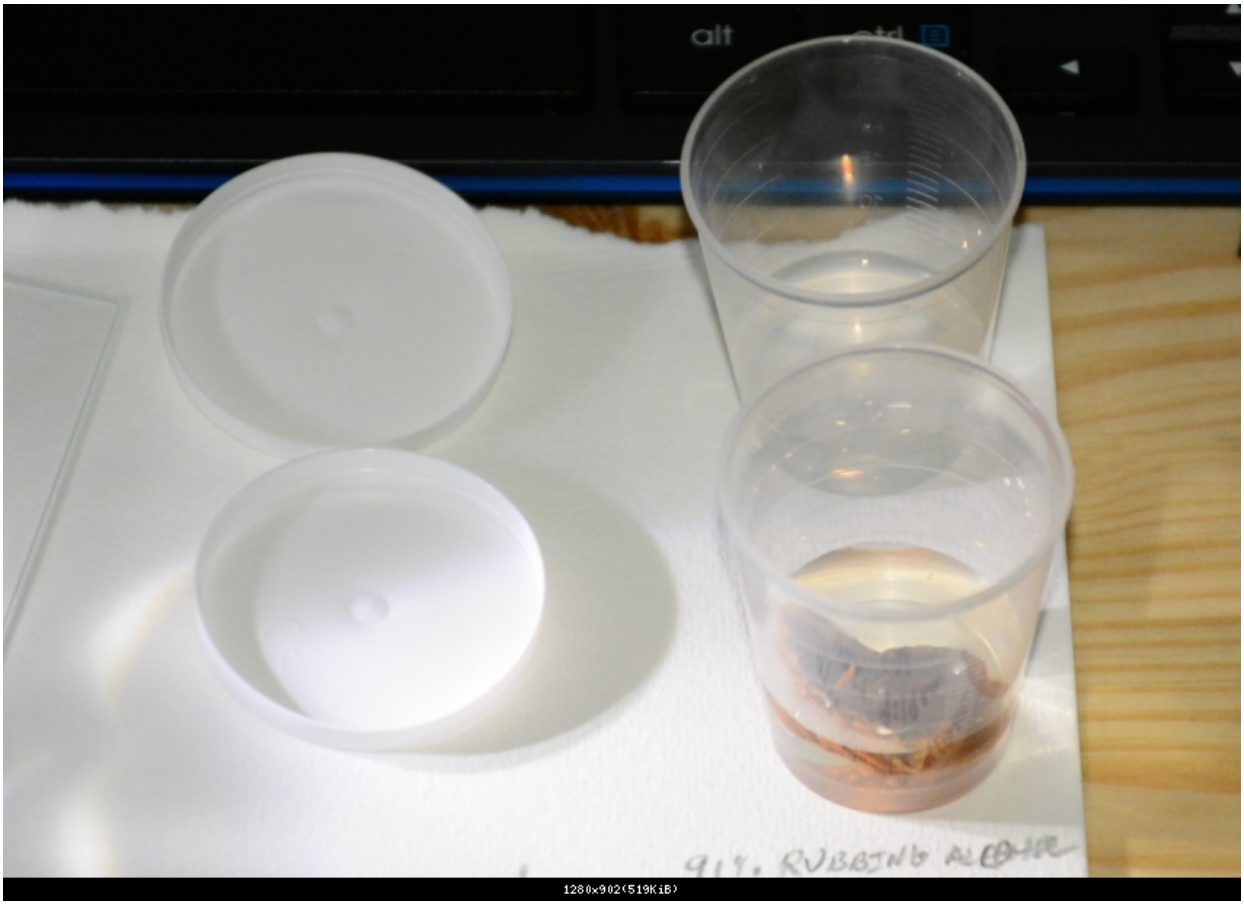
Rehydrating A Complete Cap With Gills

In addition to working with a single gill, it's good to also work with a gill cross section using the entire pileus and lamella. The easiest method to this follows.

First, break off the stipe so only the pileus and lamella remain. In a small beaker, add enough 91% rubbing alcohol to allow the cap to be submerged completely in the alcohol. Depending on the size of the mushroom and species, it should take between 10 and twenty minutes for the tissue transition from a dense, hard mass into soft, rehydrated tissue.



After submerging in rubbing alcohol, fill a separate small beaker with distilled (or DI) water. Transfer the mushroom tissue into the H2O and soak for ten additional minutes.



The material is removed with curved forceps (also known as jeweler's curved forceps) and cut in half so we're working with exactly one half of the mushroom cap.

From the above section, extremely thin cross sections can now be made. This will provide a view of the pileipellis, pileus trama, gill trama, subhymenium, and limited areas of the gill face.

When Mushroom Tissue Is Challenging To Section

If you're having difficulty performing a cross section on rehydrated fungal tissue, you may benefit from *Clémençon's Solution*. This is used to rehydrate dried fungi tissue and make it easier to cut sections. The formula is 80ml of 96% ethanol (or industrial methylated spirit), 20 ml of concentrated ammonia and 1gm of glycerol. The dried material is soaked in this until it is sufficiently softened. It is then removed and allowed to dry for a while when it should be "waxy" and able to be sectioned. A final soak in 10% ammonia may help to expand the section, but is not always necessary.

When Mushroom Tissue Is Dark To View

There are two key words worth providing that may help when dealing with very dark tissue: *Clearing Agents*. There are a number of different clearing agents worth experimenting with and it should be noted here that it would be beneficial to mycologists (and the world itself) if we begin sharing knowledge with one another more coherently and more freely. Clearing agents have not received enough attention in mycology texts, including during the formal descriptions (and microscopy) of new fungal species.

Standard solutions of KOH (Potassium Hydroxide) at 3%, 5%, and 10% concentrations are considered clearing agents, and in many species - perhaps most - KOH will be sufficient for describing fungal cells. In the event alternatives are needed, one or more of the following chemicals may provide the answer: Chloral Hydrate, Visikol, Xylene, Histo-Clear, Lactic Acid, or Methyl Salicylate.

When Mushroom Tissue Requires More Time To View

When working with tissue that simply requires more lab time than other collections, it may be of benefit to mix 10% Glycerol with a 5%-10% KOH solution. Glycerol will help extend the lifespan of the KOH before it begins to precipitate (crystallize).

Dried Material Versus Fresh Material

It is appropriate to ask, "Are microscopic observations identical in rehydrated material and freshly harvested material?"

It is always preferable to work from new, freshly harvested material. Observation details from fresh material versus dried/rehydrated material will always have more precedence and value - representing the mushroom with greater authenticity and clarity.

Returning From The Field: An Approach To Microscopy

It's easy to confuse collections once you've returned from the field and begun contemplating whether or not to perform microscopy.

The best approach I've found begins in the field. You must have a good digital camera, a consistently-used collection container, and a system to separate collections. Everything should be done in chronological order starting with the camera. The first collection is marked by a particular photograph that tells you a new collection has begun. In between each collection an intentionally unique photo is taken to remind you of separation. Likewise, in the collection container (used from the bottom left slot to the top left slot then down to the second column from bottom up, each new collection gets a new slot. If necessary, a marker might be helpful to write on top of the surface of the container.

Once I've returned from the field the photos are digitally organized on the lab computer with a main folder (dated - with location) and several subfolders in chronological order for each respected collection.

Microscopy should be performed within 24 hours (with the help of refrigeration). Otherwise the specimens should be intentionally dried and microscopy performed afterwards. It should be noted that some collections will be riddled with insects and larvae. This is probably the only true opponent of microscopy. Sometimes a collection that looks absolutely pristine turns out a day later to have been the home to a harmless but unwanted battalion of tiny life. There are two ways to deal with this, and you will have to use your judgment as to which route to take. The first is to rinse off the collection(s) under running tap water for a minute or so, using a careful but effective approach to rinse of insects. The second method is to put your collections, immediately, in a dehydrator around 105 degrees fahrenheit until fully dried, then perform microscopy. You can also try to perform microscopy anyway (regardless of insects) and 99% of the time this works fine. Do not attempt to freeze fresh mushrooms for microscopy.

Below: The collection container with breathable holes pre-designed or hand-drilled

By the time you've returned from a typical mushroom hunt (and gathering the fungi in your container) the container can immediately be placed in the fridge, so long as the container has several holes to provide air exchange. This will allow you with roughly 24 hours to perform microscopy without having to dehydrated the collection(s). Individual mushrooms can be taken in the container while the rest of the collection(s) remain temporarily refrigerated during this 24-hour time frame. If you work very fast and have been performing microscopy for several months you can keep the container by your desk and skip refrigeration.

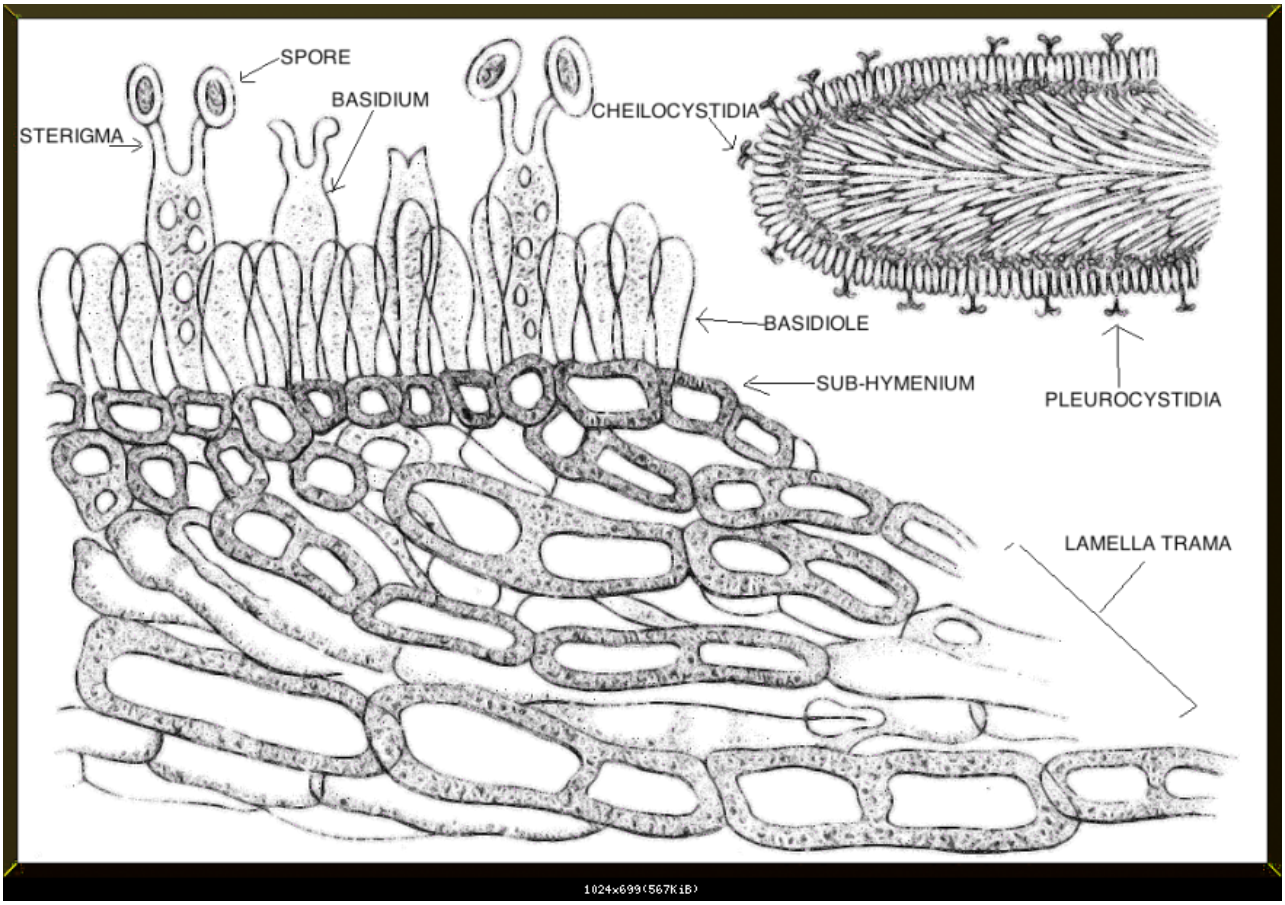
Before microscopy, macroscopic measurements may be taken with a standard mm ruler. Field photographs lacking clarity or detail can also be re-shot indoors before microscopy is performed. In general, I prefer the first microscopic observations to be based on a preparate cut-out with spores first, cheilocystidia second, pleurocystidia third, basidia fourth, and the pileipellis fifth. Additional features can then be addressed in the same section or with new slides and sections (including different mounting mediums and stains).

Layers Of The Gill: Introducing The Hymenium Layer & Hymenophore Layer(s)

The *hymenium* layer is the top layer of a gill in which basidia, spores, and cystidia are found. It is considered the reproductive layer (the spore-bearing surface of the gill). The hymenium is considered the outer surface of the gill and therefore not part of the gill trama.

Underneath the *hymenium* layer another layer called the *hymenophore* layer is found. This layer is actually composed of usually two to three layers. This hymenophore layer is considered "sterile" (or non-reproductive). This layer should be viewed initially at relatively low magnification (roughly 10-40x) for first time users, in order to gain a point of reference.

The **hymenophore** layer includes the *hymenophoral trama* which is synonymous with the terms *gill trama* and *lamella(r) trama*. It is usually not one layer but two, consisting of first the ***subhymenium*** (a narrow zone of small, short hyphae), then the second layer - the ***hymenophoral trama proper***(consisting of hyphae which project downwards from the pileus).



The way in which the lamella trama hyphae are arranged (as well as the arrangment of the subhymenium) is helpful in high-level identification. A group of patterns has been established to describe these hyphae patterns.

In order to view the **hymenophoral trama proper** you will need to make any type of gill gross section anywhere along the mushroom pileus at an almost perfect downward, straight cut. It may be best to observe a gill cross section taken from near the center of pileus. When in doubt view multiple sections from multiple areas.

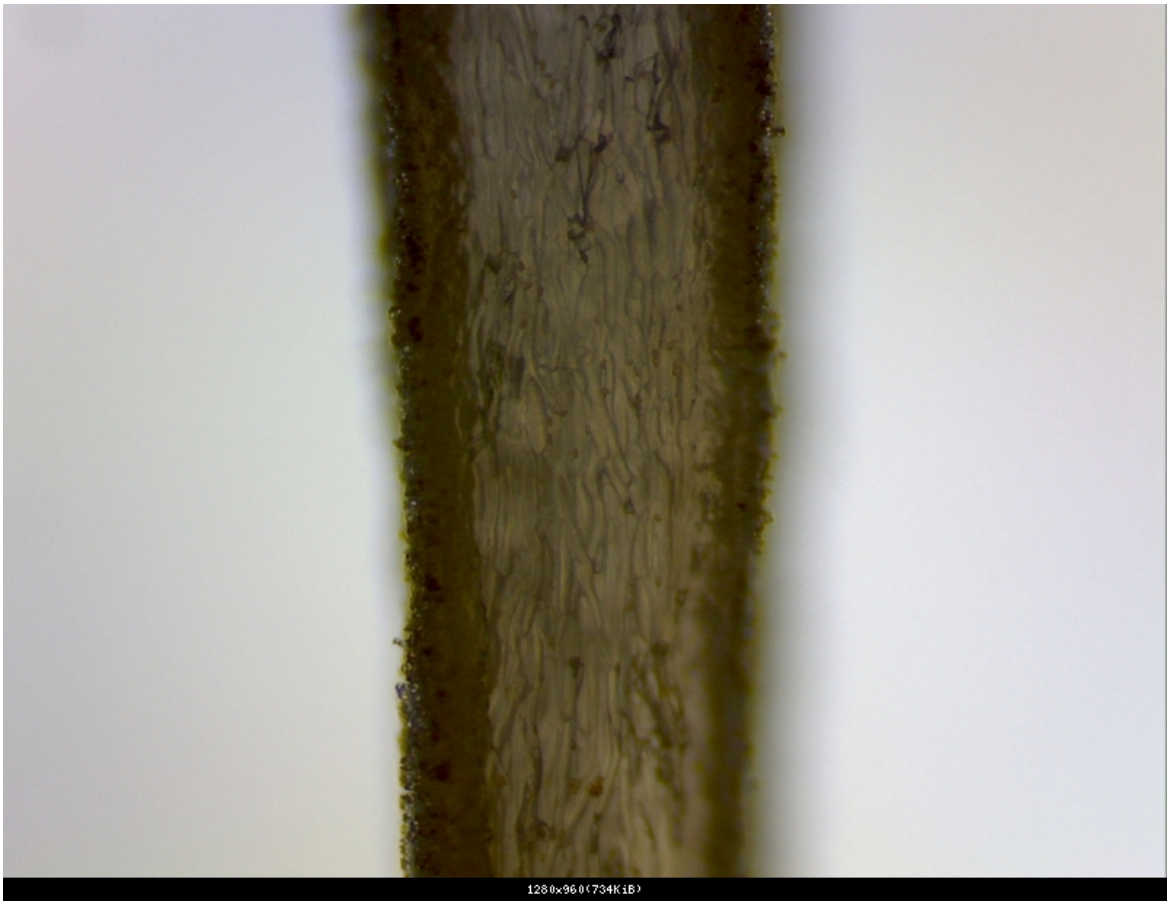
To view the gill trama you may be better off using no liquids and no cover slip and simply viewing at low magnification (between 40x and 400x). The right light level and the right iris diaphragm (condenser) setting to be able to see the details of the hyphae. The main aim is to determine the pattern type of the hyphae that make up the gill trama proper.

Here are the **Gill Trama** pattern types:

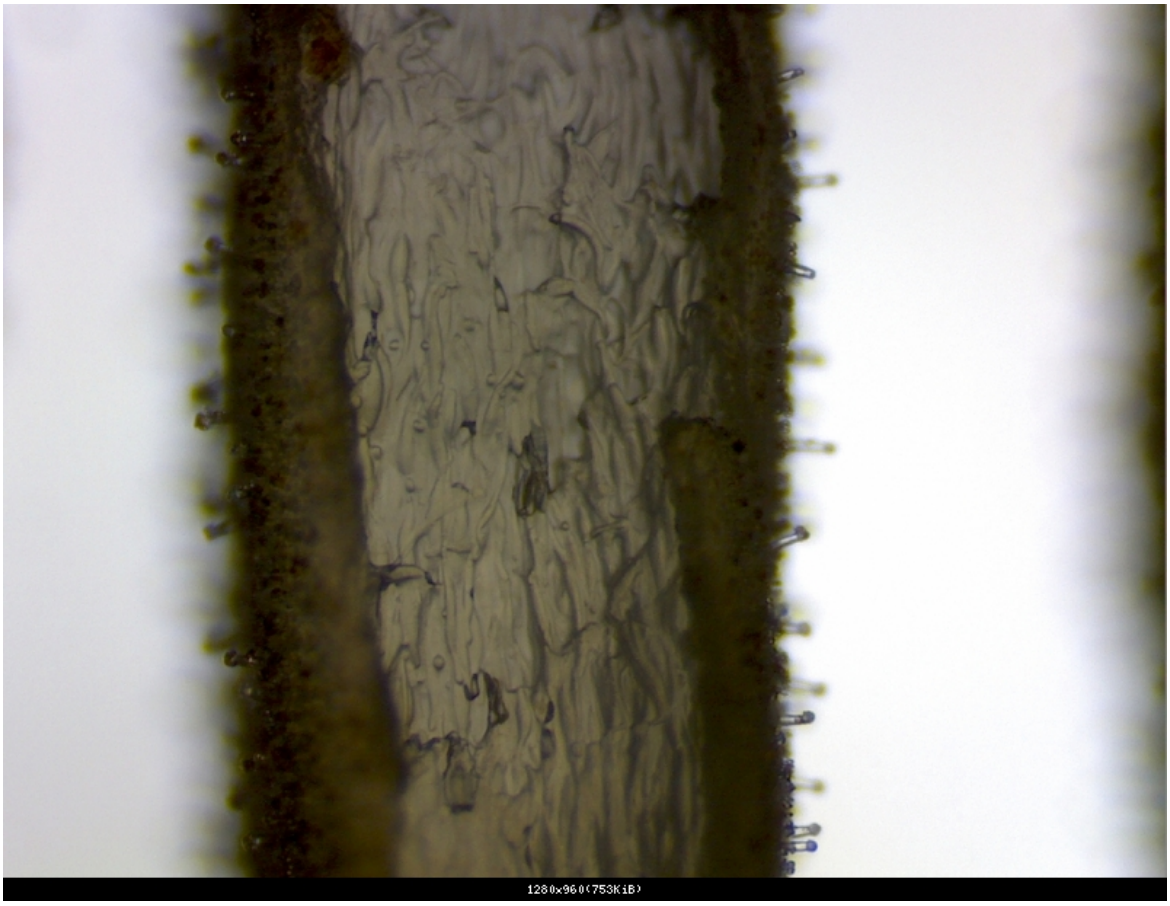
Below: Parallel Lamellar Hyphae (also called *Regular* Lamellar Hyphae or Parallel Hymenophoral Trama).

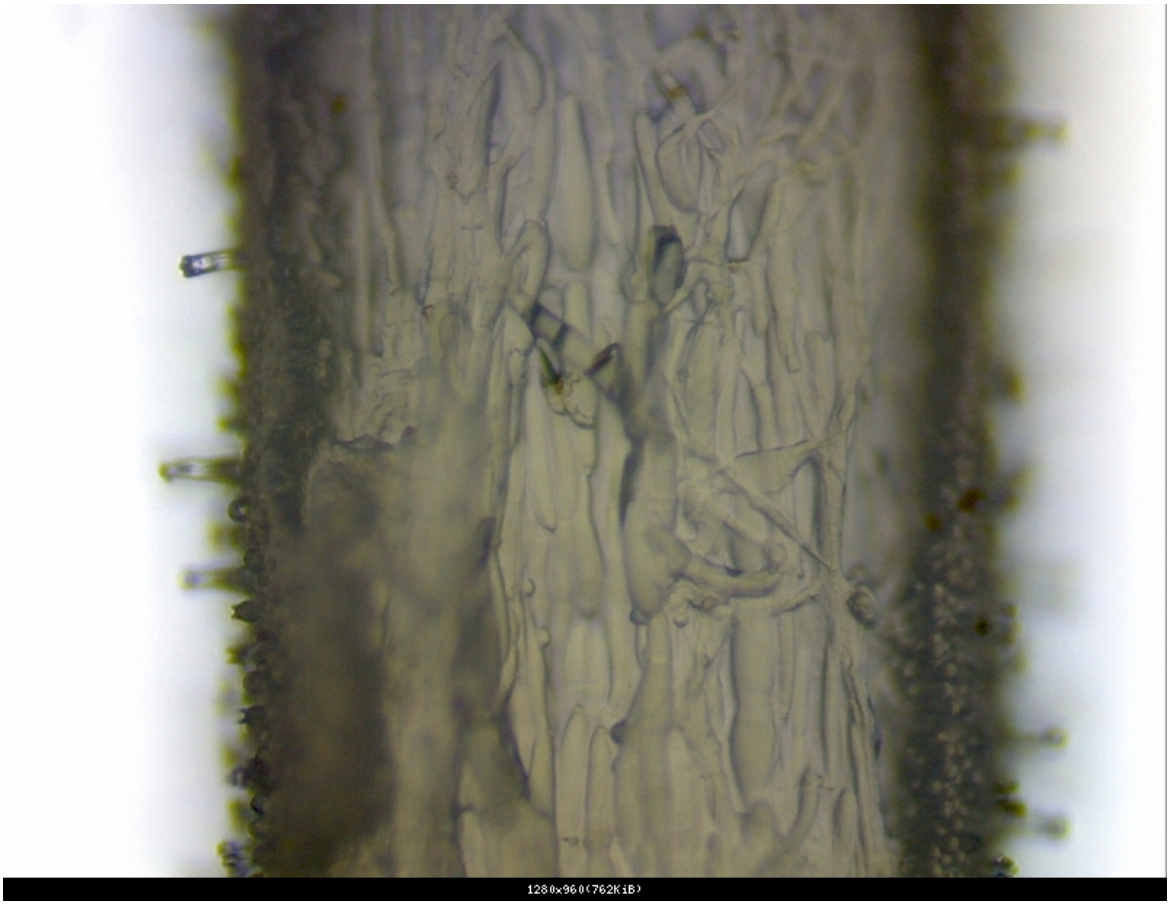
xyz

Below: Subregular Lamellar Hyphae (almost regular by overlapping and criss-crossing, otherwise similar to parallel hyphae pattern)



Below: Interwoven Lamellar Hyphae (also called *Irregular* Lamellar Hyphae Pattern)





Below: Divergent (Bilateral) Lamellar Hyphae Pattern

xyz

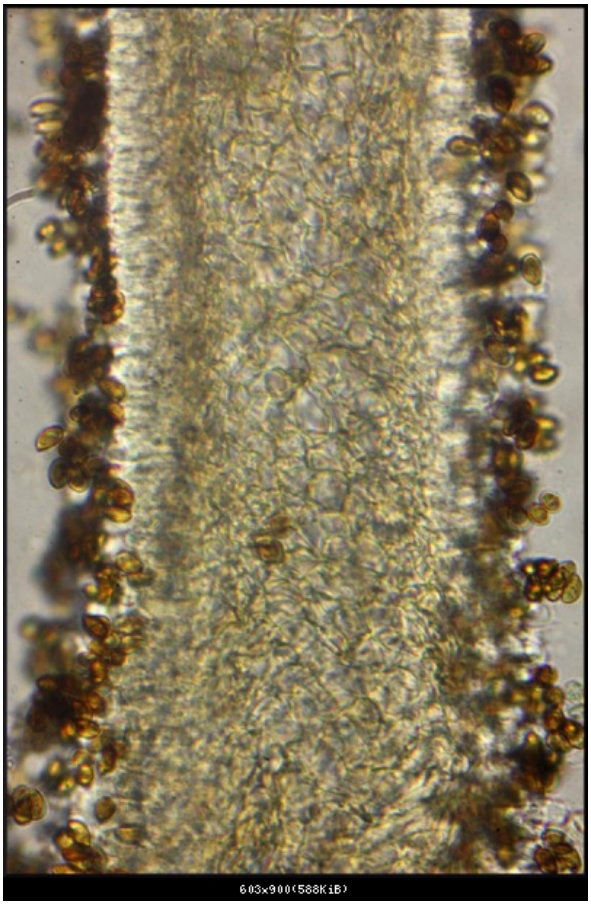
Below: Divergent (Bilateral) & Multi-Sized Lamellar Hyphae Pattern

xyz

Below: Convergent Lamellar Hyphae (*Inverse* Lamellar Hyphae Pattern)

xyz

Below: A *subcellular* lamellar trama pattern (*Psilocybe subaeruginascens*) courtesy Alan Rockefeller

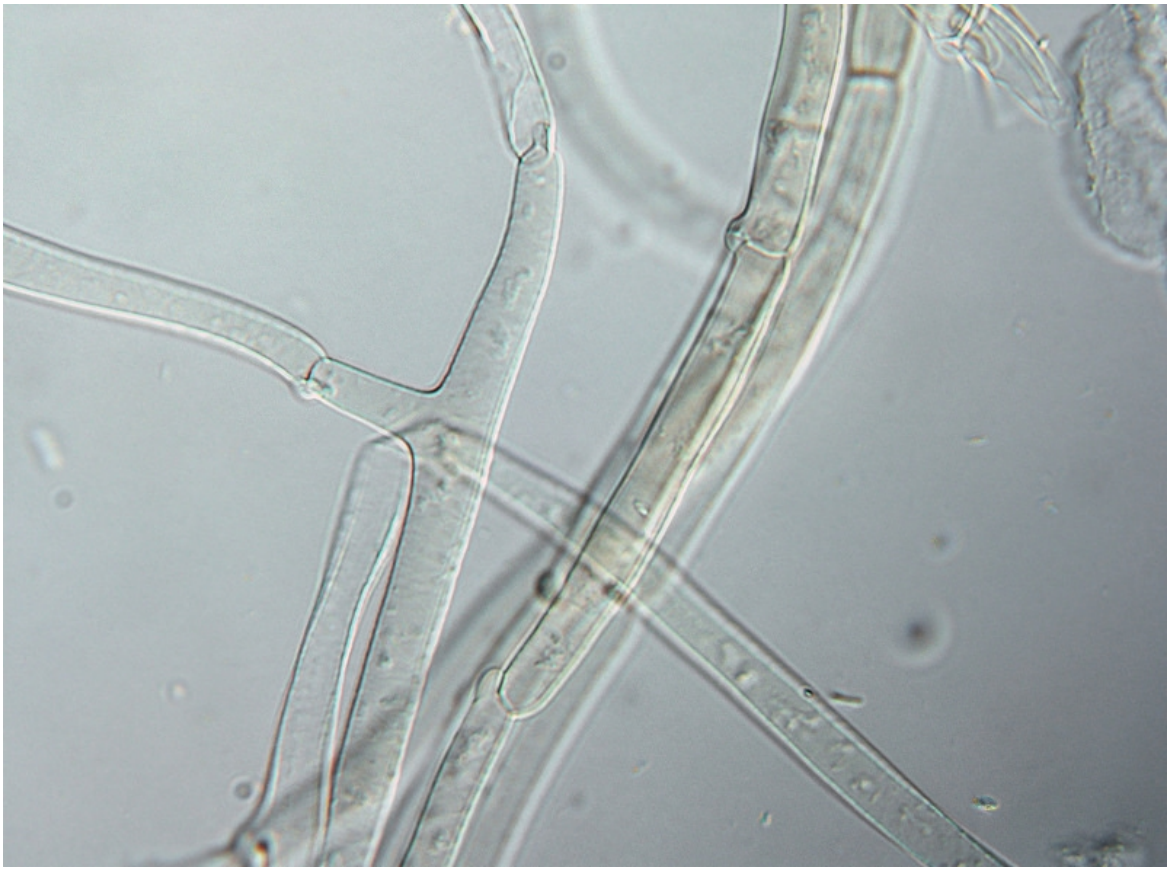


In many collections, the gill trama may be very difficult to observe through a compound microscope. A stereoscope can be used and may provide better vision. If this occurs - and it's likely - a smaller section may be useful. Instead of an entire cross section involving several gills, a single gill (or perhaps a few single gills organized properly) cut into very small sections (using a gill cross section technique first) can be viewed. It is also ideal to use a scalpel to make all sections if obtaining clear access to the trama is becoming difficult. The scalpel is moved in a gentle, smooth rolling motion downward by by allowing the blade (not the strength of the user) to eloquently section through the material - soas not to alter the pattern of the hyphae.

These smaller sections can be mounted in GSM or SDS Congo Red, allowed to rehydrate for at least 3-4 minutes, and then - once the hyphae has expanded, a cover slip can be gently added without crushing the material. A crush mount cannot be trusted to observe hyphae patterns.

In addition to photographing or documenting the gill trama pattern, also make note if the subhymenium is gelatinized, and if there are clamp connections present in the hyphae.

Below: Clamp connections can be seen in this microphotograph courtesy Gravija.



Below: A gelatinized subhymenium courtesy of zzz.

xyz

The Subhymenium

The *subhymenium* is a layer of hypha cells immediately beneath the hymenium. This layer of tissue is visibily distinct from the lamella trama. The following subhymenium (=sub-hymenium) patterns have been established:

Ramose

xyz

Above: A ramose subhymenium

Inflated-Ramose

xyz

Above: An inflated-ramose subhymenium

Coralloid

xyz

Above: A coralloid subhymenium

Cellular

xyz

Above: A cellular subhymenium pattern

Other forms may very well exist and I encourage others to study and publish them.

Clamp Connections VS Septa: Seeing The Difference

xyz

Viewing & Analyzing Hyphae Within A Gill

The first part of any discussion on hyphae should include a clearer understanding of what hyphae are.

Hyphae are the building blocks of both mycelium and the entire mushroom. Hyphae have the capability to merge into other hyphae, resist other hyphae, form into primordia, and develop (into) all components of the mushroom body. They are entangled and interwoven throughout the entire mushroom, sometimes forming patterns.

There are three types of hyphae tissues that the microscopist should be aware of: Fundamental Tissue, Connective Tissue, and Conducting Tissue. Fundamental Tissue is composed of thick-walled, skeletal, binding hyphae. Connective Tissue is made of thin-walled hyphae of which the generative hyphae from the major component. Conducting Tissue has elements that transport metabolic substances which may be excreted or secreted. Most gilled mushrooms have a *monomitic* system along with these three tissues.

Creating A Section For Viewing Lamella (Gill) Hyphae

In order to see beneath the hymenium layer of the gill a preparate cut-out will not provide the angle or section type required. Instead, a gill cross section must be made. This section will cut through the gills vertically - in an extremely thin cut - allowing for visibility inside the gill. The gill trama should quickly become obvious and discernible from the hymenium because of its lighter, almost grid-like appearance.

Once this section is made it can be viewed in one or multiple liquids. It may be best to start with KOH and if visibility is insufficient add a drop or two of lactophenol cotton blue or lugol's dilute solution. Congo red can also be used for studying the hyphae pattern inside the gill. Instead of using KOH you may wish to first use 70% alcohol and before it dries out add one of the stains mentioned above.

The Pileus Trama and Pileipellis

The outermost layer of the pileus is called the *pileipellis*. There are a number of synonyms that are used for pileipellis: Pileus cuticle, pellis, rind, skin, and cortical layer (some of these terms have been used to describe the outer layers of the stipe and gills, but to avoid confusion it is best to use "pileipellis" whenever a reference to the outermost layer of the cap is made).

The pileipellis is composed of one or more layers. The first of these layers is the *suprapellis* - the outermost layer of the pileus. Some mushrooms have only this one layer, the suprapellis. Other mushrooms will possess one or more additional layers.

When additional layers are present, they are labelled in order of occurrence. At all times the outermost layer is referred to as the suprapellis. The next, inward layer (when present) is called the *subpellis*. A third layer, if present, causes a bit of a mixup in name order: The suprapellis remains the outermost layer while the next, middle layer is now called the *mediopellis* and the third, most inward layer is now called the *subpellis*.

You may wonder at this point what comprises the *pileus trama* - a more relaxed term used to describe to general inner portion of the pileus. The pileus trama is located between the pileipellis (the pileus surface layer(s) and any gill or stem tissue.

How To Create A Section For Viewing The Pileipellis

The pileipellis structure provides a very important and distinguishable piece of knowledge to identify down to species level. There are two important sections to view the pileipellis: A pileipellis scalp section and a pileus cross section. Important: This area of the mushroom requires thorough examination and multiple sections.

Make Your First Pileus Pileipellis Scalp Section

Above: A very tiny, almost square-shaped section is removed from the center of the cap of this *Agrocybe* (ad int.) specimen.
It will later be compared to scalp sections between the center and the pileus margin.

Center Section: You're going to create a very thin, small section taken from the surface of the pileus, at the center. The surface of the pileus is examined in this type of section - with the outer surface placed face-up on the slide. To make this section: Use a fresh, sharp razor blade and make two very fine incisions - parallel to one another - about 5mm long. Make a third incision going the opposite direction, creating a U-shape. Grab the loose end using forceps or tweezers that is opposite of the one uncut area of the U. Pull free, tearing the material. Examine the edges under a microscope at low magnification at first.

Off-Center Section: After placing the above section on a slide, proceed by making two additional sections from in-between the pileus center and the pileus margin. You will want to consider differences in structure between these different sections and note them.

How to Make a Pileus Cross Section

In addition to the pileipellis scalp section noted above, you can alternatively examine the pileipellis with a cross section.

Make a gill cross section just as you normally would - the thinner the better. Remove the gill tissue and use the remaining pileus tissue, preferrably very thin, for microscopy.

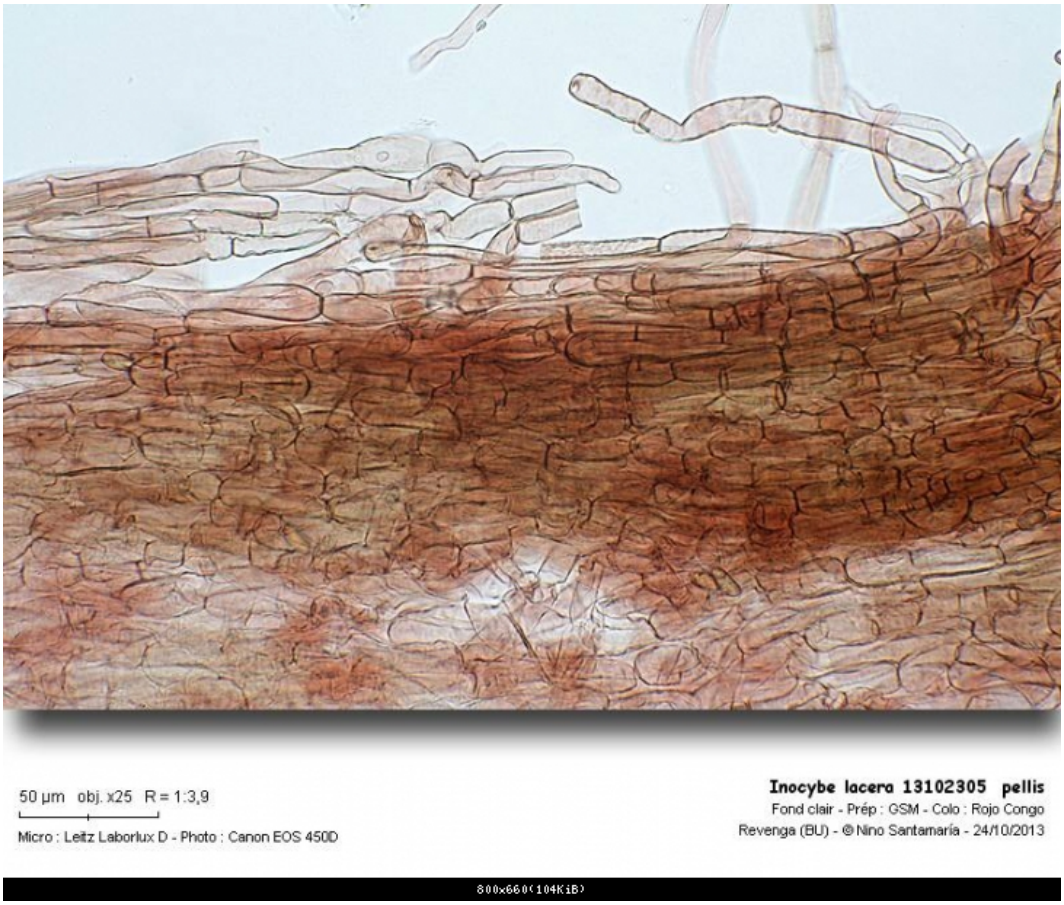
The pileipellis area can be viewed in the same section that is made from a *gill cross section* and a *preparate cut out* (when the size of the gill will allow and the section is made to include it). This

section should occur, once again, with a section directly through the center of the pileus and other sections that are off-center.

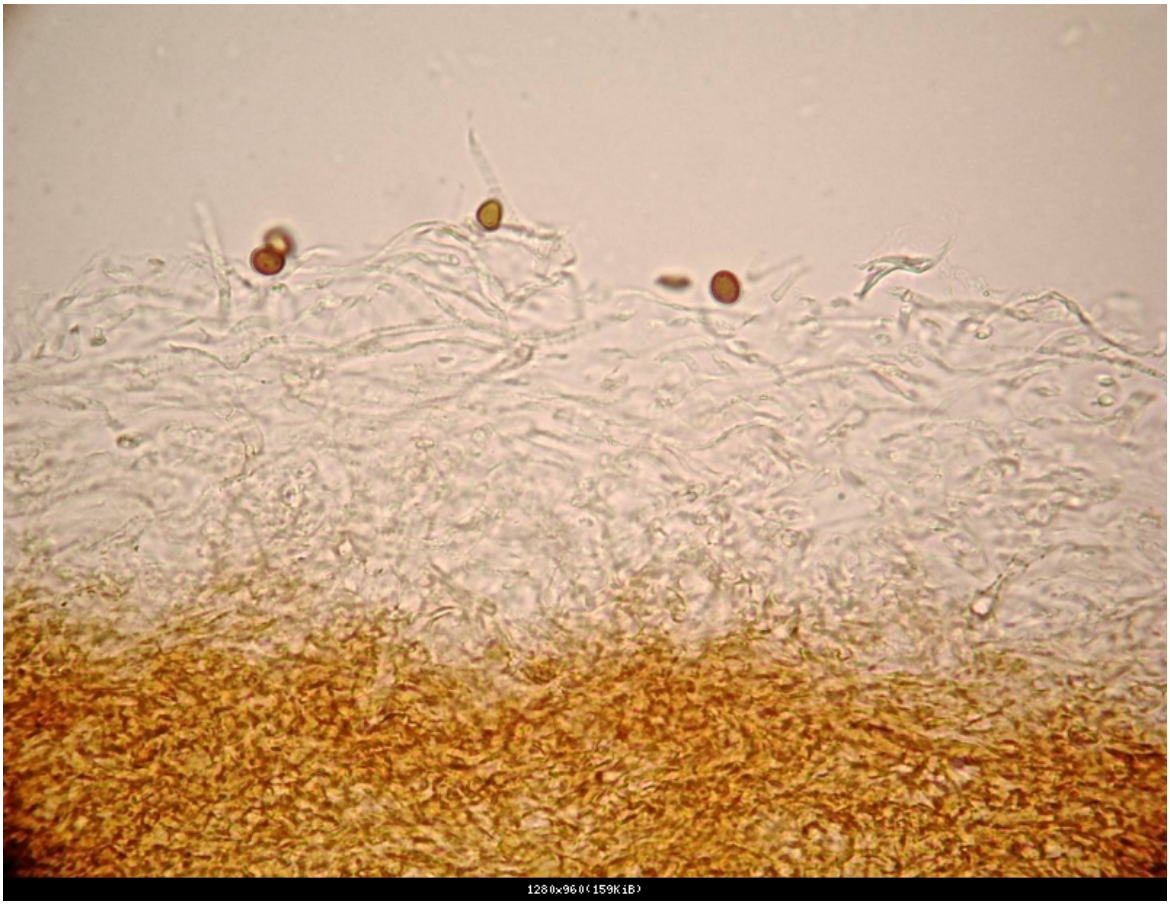
Note: Always note what stains and mounting liquids were used when presenting micrographs, as this will have an impact on the appearance of the pileipellis!

Pileipellis Structure Types - Recognizing Patterns of the Pileus Pileipellis

Below: Cutis Pileipellis (*Inocybe lacera* courtesy Nino Santamaria)



Below: Ixocutis Pileipellis (*Psilocybe pseudoaztecorum* courtesy Alonso Cortés-Pérez)



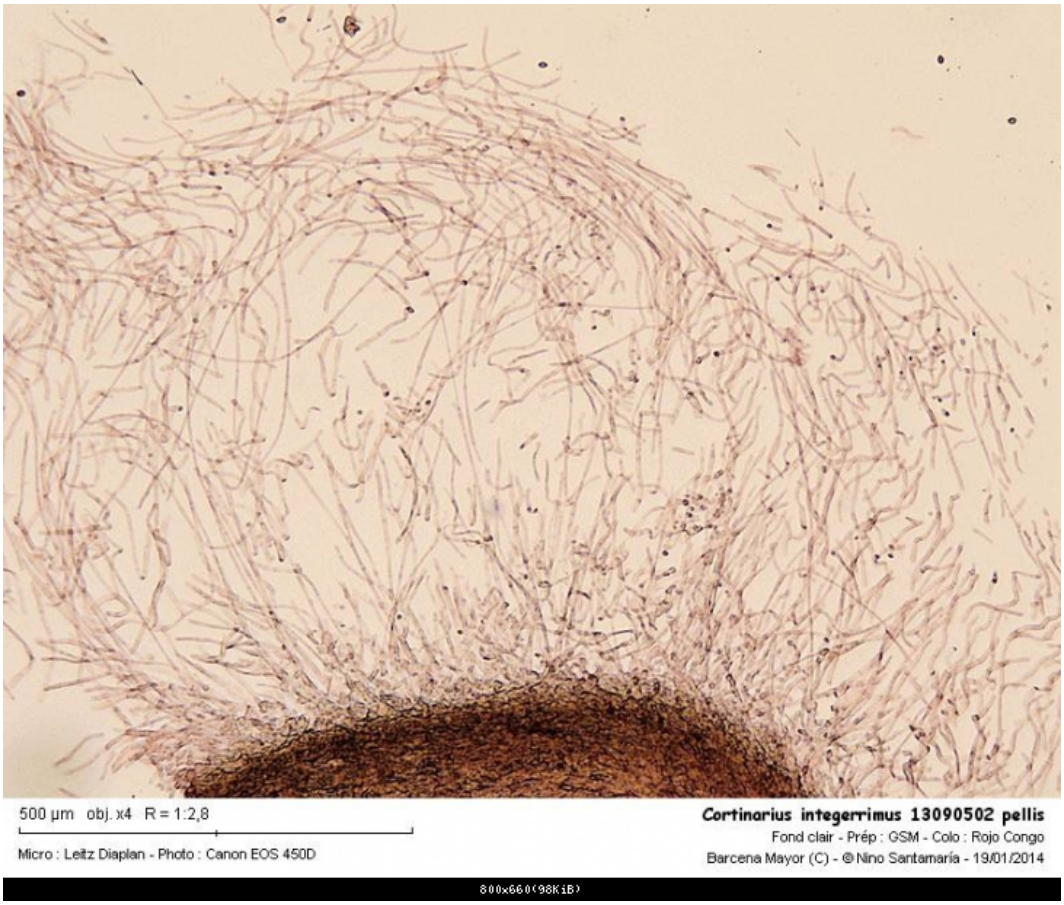
Below: Trichoderm Pileipellis (*Lepiota subincarnata* courtesy Nino Santamaria)

Below: Intricate Trichoderm Pileipellis

xyz

Below: Irregular Trichoderm Pileipellis (*Russula aurea var. axantha* courtesy Nino Santamaria)

Below: Ixotrichoderm Pileipellis (*Cortinarius integerrimus* courtesy Nino Santamaria)

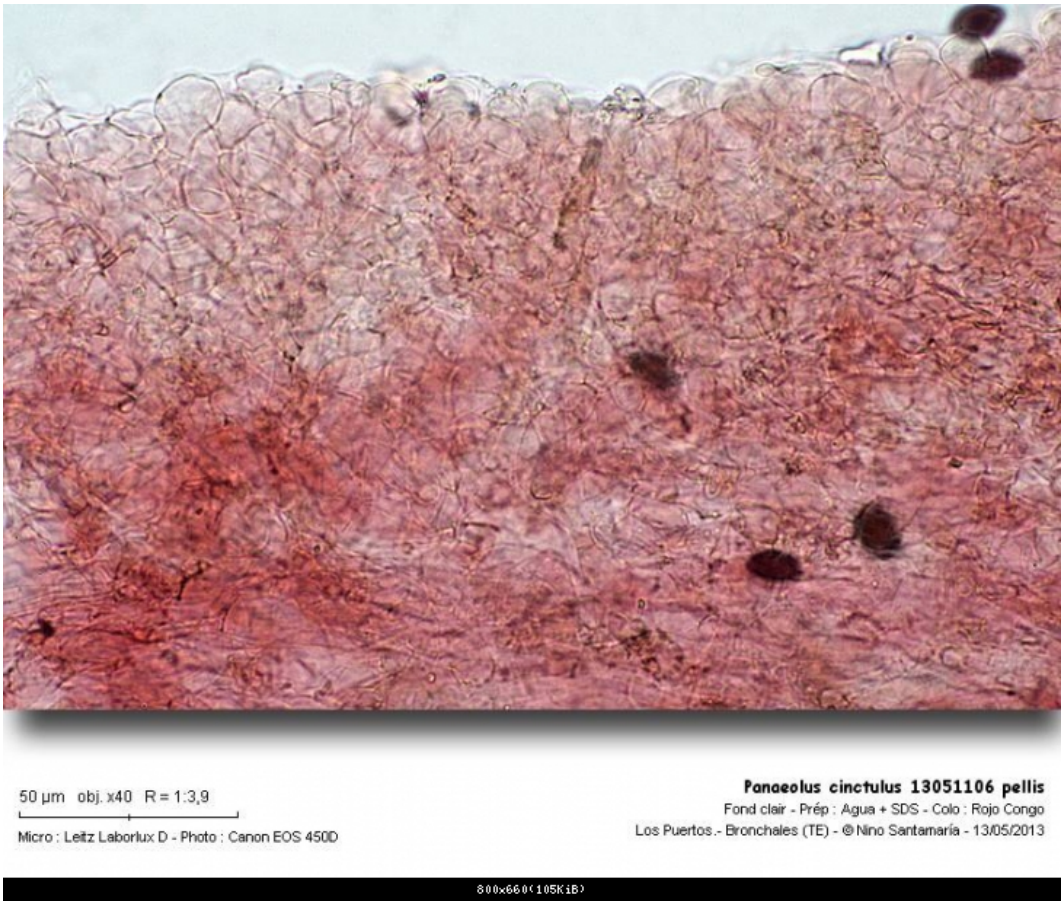


Below: Trichohymeniderm Pileipellis

xyz

Below: Euhymeniderm Pileipellis (*Entoloma sp.* courtesy Nino Santamaria)

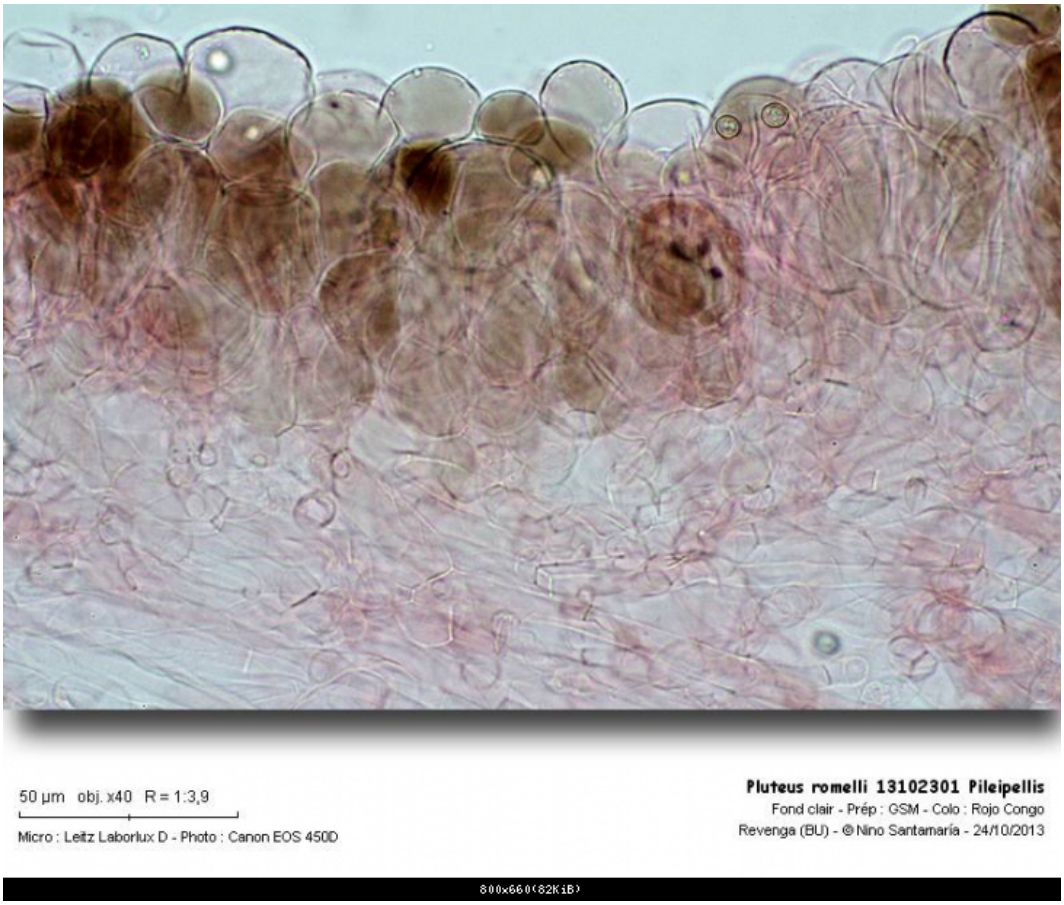
Below: Epithelioid Hymeniderm (*Panaeolus cinctulus =Panaeolus subbalteatus* courtesy Nino Santamaria)



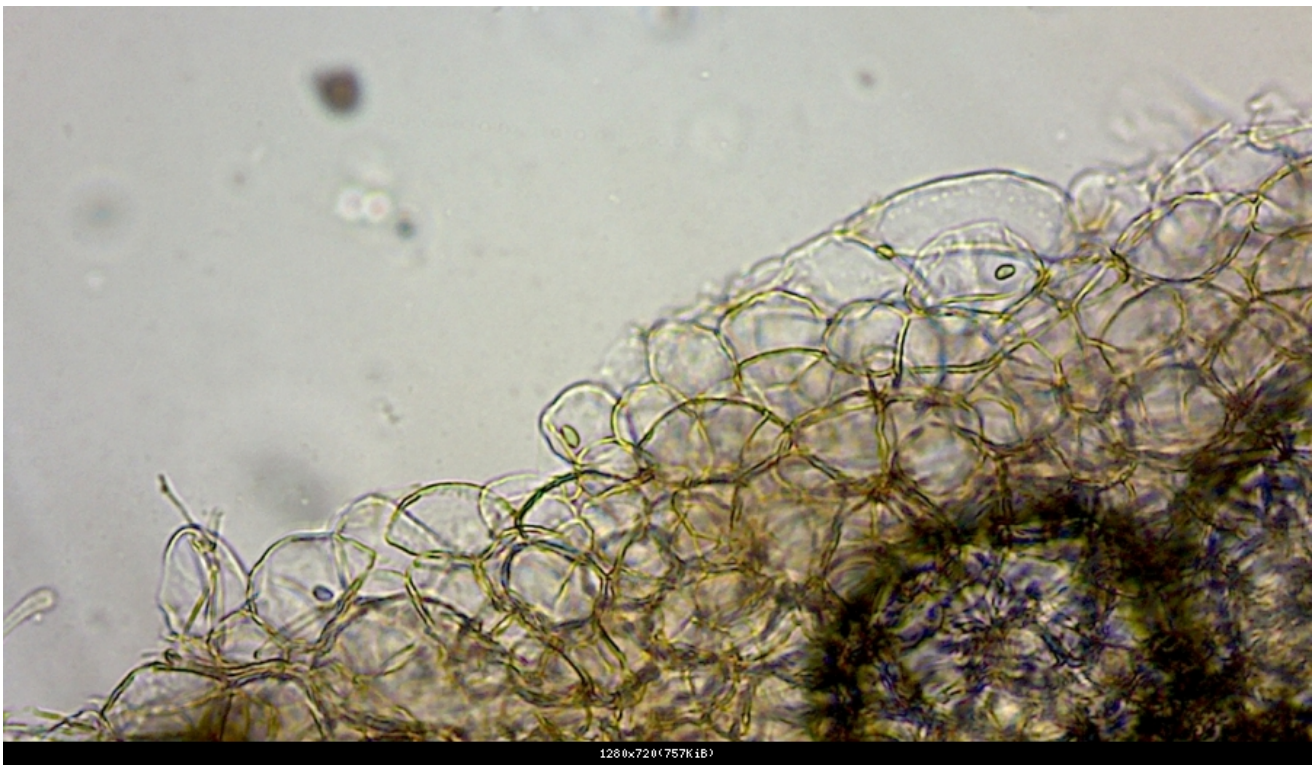
Below: Pileipellis With Transition Between Hymeniderm And Epithelium

xyz

Below: Regular Epithelium Pileipellis (*Pluteus romelli* courtesy Nino Santamaria)



Below: Irregular Epithelium



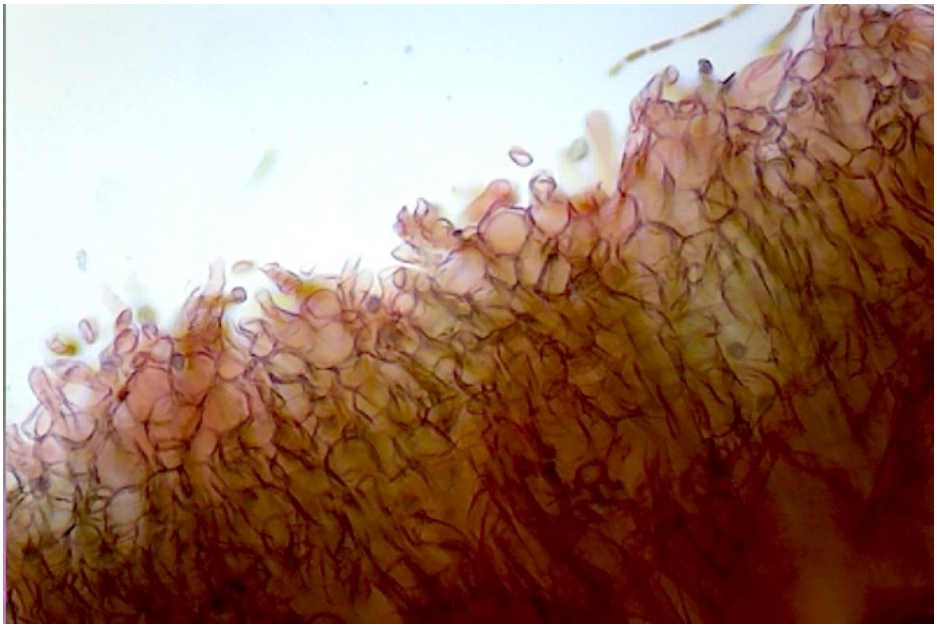
How To View & Measure Pileipellis End-Hyphae, Pileocystidia, & Circumcystidia

Measure the length and the width of at least 30 hyphal end cells and again calculate averages and the quotient. To be clear, if you see a hyphal strand with several clamp connections, you'll only measure the final cell attached. Determine the longest length and widest width with each cell measured.

It should not be confused with circumcystidia (cystidia on the pileus margin). Look along the apex of the pileipellis for cells or clamp connections (of hyphae) extending outwards. A micrograph will speak louder than several paragraphs of technical terminology in many instances.

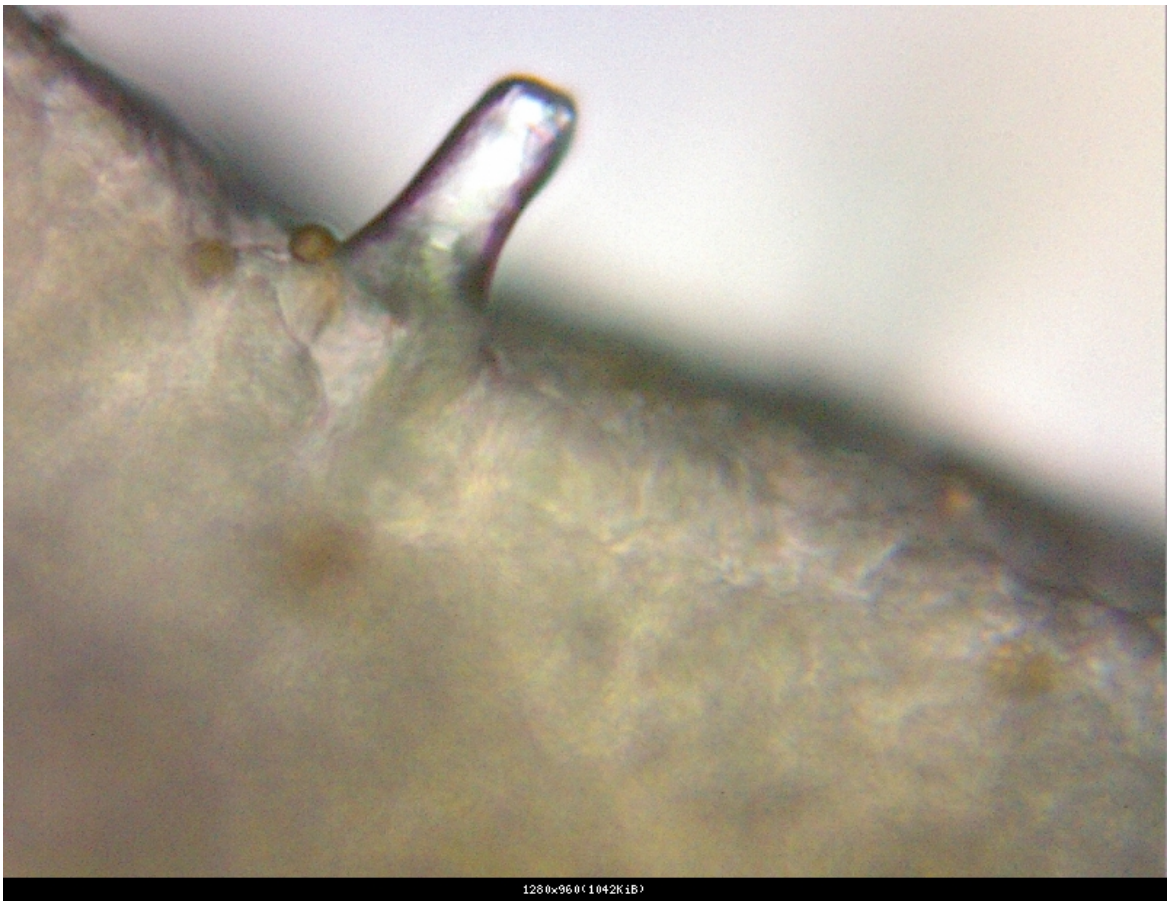
The first thing the microscopist should be aware of is whether or not to use a mounting agent such as KOH. This will definitely impact the appearance and should be noted when sharing your observations with other mycologists. A general approach should begin with making a very thin gill cross section and simply observing it on a slide without any liquids (and without a cover slip).This will not not require the 100x objective and usually will not require the 40x objective. Afterwards the unmounted material has been examined, apply 3% KOH and again view this material without a cover slip. Finally, if you wish to move on to finer detail, apply a little more 3% KOH and a cover slip and begin using the 40x and 100x objectives as needed.

Below: A micrograph of the apex of the pileipellis *(In an Inocybe species)*



Pileocystidia (cystidia emerging from the pileipellis) are not found on most gilled mushrooms. When not present a micrograph of the apex of the pileipellis should be taken. The end-hyphae in the pileipellis can sometimes help in identification. Pileocystidia occur on the cap's surface (excluding the margin of the cap).

Below: Two images of a pileocystidium at different magnifications *(Inocybe geophylla var. lilacina)*



Note: Pileocystidia could only be observed in this collection when no mounting liquids or slip was applied.

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Circumcystidia are similar to pileocystidia - they occur, however, only on the margin of the cap's surface (the perimeter of the cap) as opposed to the entire cap surface area. When pileus cystidia are found away from the cap margin they are considered pileocystidia.

Below: Circumcystidia from the species ZZZ

xyz

Viewing Patterns of The Pileus Trama

xyz In between the pileipellis and the subhymenium is the pileus trama. This area is also composed of hyphae and can be labelled based on its hyphal pattern. These hyphae will connect downward from the pileus trama and directly enjoin the hyphae that compose the gill trama. There is no definitive division line separating these two layers although once the hyphae have gone beyond the gills and into the cap they are correctly called hyphae of the pileus trama.

To create this section, two methods can be used and both are nearly identical: Create a very thin gill cross section that includes the entire cap, or create a gill cross section and make another cut removing all of the gills. A third cut can also be made to create a smaller area to examine. A stereoscope (dissecting microscope) may be required to see some tramas.

In addition to the pattern of the pileus trama hyphae, the occurrence of clamp connections, the thickness of the hyphae walls, their color (pigmentation), and their reaction to chemical agents such as KOH and Melzer's - all have value in identification.

Below are the established pileus trama patterns (forms) - there are intermediate types (patterns which are a mixture of two patterns such as *subregular to irregular*.

Below: Irregular pileus trama pattern

Below: Interwoven pileus trama pattern

xyz

Below: Radial pileus trama pattern

xyz

Below: Loosely Interwoven pileus trama pattern

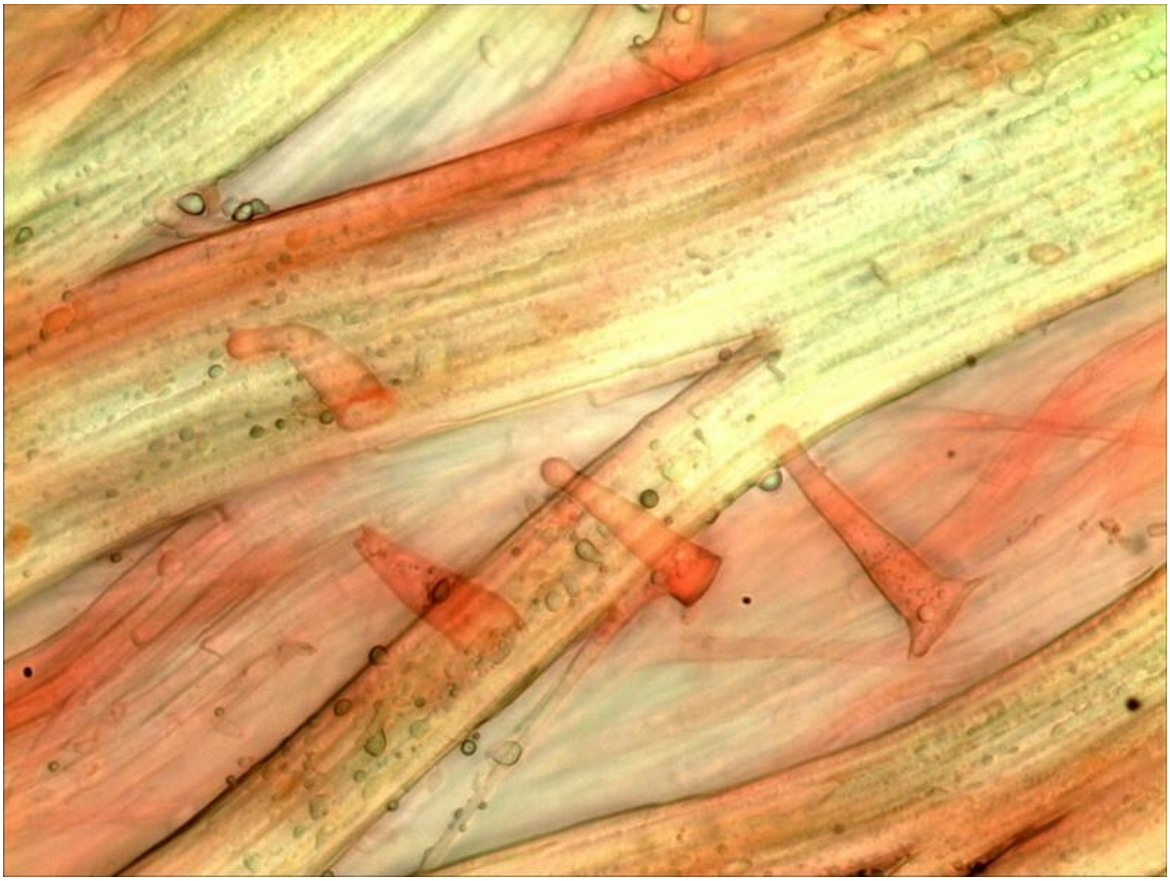
xyz

Below: Distincly Interwoven sensu Hesler pileus trama pattern

xyz

The Stipe Surface (Stipitipellis): How To View & Measure Caulocystidia & Microcharacters of Value

Below: *Strobilurus stephanocystis* stipe cystidia (caulocystidia). Courtesy Anton Soklič collection.



Caulocystidia are cystidia found on the outer surface of the stem on a few species. They can be found by making a thin cut to the stem. Instead of a cross section, a *scalp section* is performed. For the sake of using a more intuitive term, I'm calling this a *surface section*. The goal is not to have a nice looking slice of the stipe like when preparing/chopping celery or carrots for a salad. Instead, the goal is to get an outer area slice from the stipe somewhat similar to peeling a carrot to get rid of the dirty outer layer. You will be examining multiple sections and comparing them: One from the apex of the stipe, one just below the annulus or annular zone if present, and one at the base of the stipe.

Below: A surface section of the the stem (ie stipe scalp section) is created in the following manner

Slice off a thin section of the stem surface (usually you're looking at the upper stem, but sometimes there are features lower down) and then place it down on the slide with the **outer surface facing up**.

Some mushrooms will not have caulocystidia. It is ideal to do this using fresh-harvested, fully hydrated fungi. Start with a section near the top of the stipe. You can do multiple sections, gradually go lower down the stem. One of the identifying features in the genus *Inocybe* is to see how far down the caulocystidia can be found on the stem. When handling mushrooms that are going to be viewed under a microscope for caulocystidia, try to avoid handling the stem (hold it by the top of the pileus and the very bottom of the stipe).

Measurements are rarely, if ever, taken for caulocystidia. The important things are knowing if they are present, their appearance, and how far down the stem they can be found. Micrographs are helpful.

Note: Another method for sectioning the stipe for caulocystidia is to use a fresh razor blade, cut the stem as if (in concept only) one were slicing carrots or celery - but super thin and with great precision and smoothness. This should be a CD-like shape section. Lay it flat on a slide. The caulocystidia are on the outer edge if present. This method should be used as a last resort in many instances.

A Few Types of Stipe Extensions (Non-Caulocystidial Cells)

Caulocystidioid hairs: Cystidioid terminal cells of superficial hyphae on stipe, paracystidia not present among these cells, can resemble metuloids.

xyz

Cauloparacystidia: Cells on the stipe similar to paracystidia found on gill edge.

xyz

Introduction to the Stipe Trama

Stipe Trama Microcharacters of Value

Trama Pattern
Clamp Connections Present/Absent
Pigment Reaction to Chemicals

To prepare a slide a thin slice as if slicing celery or carrots (only much, much thinner) is made. This section can sometimes be made with freshly harvested collections. Intentionally drying a specimen or two for stipe analysis may prove helpful if the section is not obtainable - slicing through the dried material in order to obtain the section. The slice is placed on a slide with the outer side facing up for view, and will in many cases - due to a hollow step - have a CD shape. The material can be rehydrated or mounted in 3% KOH - allow enough time for the fluid to expand the tissue before considering a cover slip. Stains can be used as well if visibility is unclear. Adjustment of the iris diaphram (condenser diaphram) may be required and can make a tremendous difference.

It is not advised to study hyphae patterns with a crush mount (squash mount). Be gentle as well when applying the cover slip. It is possible that some tramas are visible using a compound microscope, however, it is well within reach to require a dissecting (stereoscope) microscope.

Stipe Trama Patterns

xyz

Note: This section will also allow view of the stipe pellis (stipe surface, stipitipellis) along the outer edges.

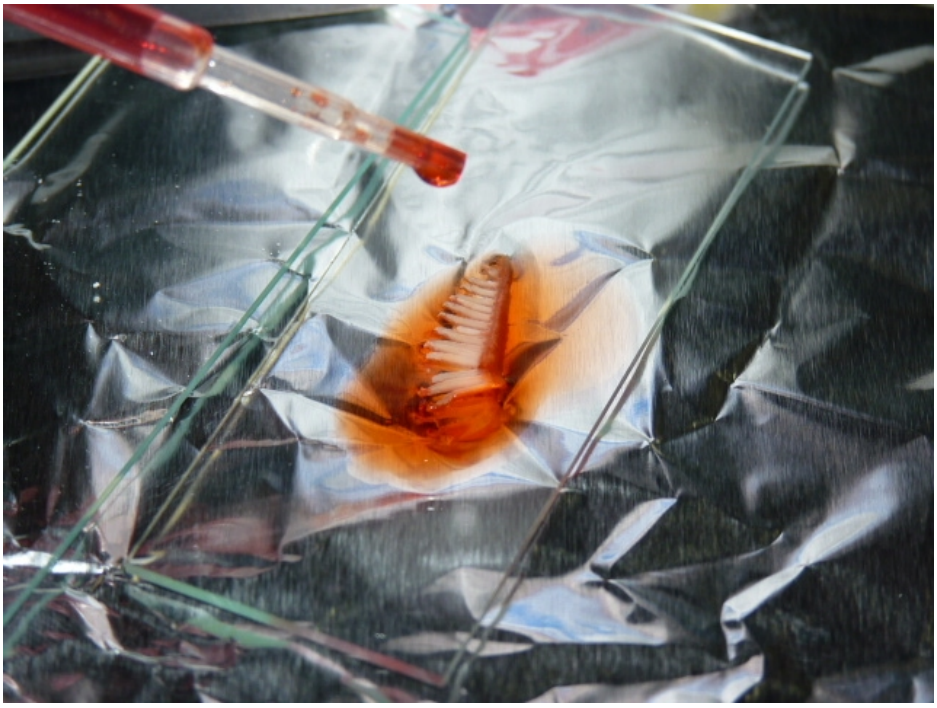
Note: Spores can sometimes be found in these sections for additional confirmation.

General Methods & Materials for Preparing Slides

Stains can visually improve the definition of cells - sometimes in crucial ways - by adding color.

The mushroom section should first be hydrated (either naturally or with KOH) then the stain is added. I usually use a drop or two depending on the size of the material and wait about 1-2 minutes. Take a napkin corner and soak up the excess stain liquid. Then mount in 3% KOH, depending on the species.

Below: A gill cross section from a freshly harvested mushroom is placed on a slide. A drop or two of congo red stain is added to improve visibility, which will help you see several features of the section. Allow the stain to settle in for 1-2 minutes roughly.



The excess stain is soaked up with the edging of a napkin. A few drops of KOH are added as the mounting liquid and then a cover slip is added.

A Common List of Stains & Mounting Liquids

☑ CONGO RED 1.0% AQUEOUS SOLUTION, 4 oz. (CH3130-4) (If this is not available a very good alternative is: Cat. No. 2250-4 Ricca Congo Red Indicator 0.1% (w/v) aqueous solution. CAS No. 573-58-0 reagent). - used as a good staining agent for cell walls, basidia, cystidia, basidioles, and hyphae (including septa)
☑ 2%, 3%, or 4% KOH (This is more of a mounting liquid but can cause color changes in some cells) - This is a very good mounting liquid used very frequently *◊☠

☑ 10% Ammonium Hydroxide can be used with some species with greater clarity of vision. It also does not crystallize and eventually become blurry as seen with KOH, although this chemical does give off a noteworthy fume and some mycologists may want to use a fume hood in its company
☑ A drop of Softsoap (Liquid hand soap) in distilled water (2oz dropper bottle) - used as a general mounting liquid when KOH is unavailable

Additional List of Stains & Uses

Use with caution and read the MSDS for each item thoroughly beforehand.

☑ "GSM" Abbreviated for: 20g Glycerol Conc. + 1g Sodium Hydroxide (NaOH) + 20ml Methyl Cellosolve + 60ml Distilled Water - noted by some as the best general mounting liquid of all ☠
☑ Melzer's Reagent - used to check spores for amyloid, nonamyloid, and dextrinoid presence. (If this is not available a fair alternative is: Lugol's Dilute Solution) - used for coloring white spores dark enough for visibility ☠☠
☑ Ammonia (Also called NH3 and Ammonium Hydroxide) 1%-25% with Water (25% is a typical amount) Mounting agent used in place of KOH. 웃 ☠
☑ Brilliant Cresyl Blue - observe spore walls with more detail
☑ 1%-10% Sodium Hydroxide (NaOH) with Water * - Can be used in place of KOH
☑ Combine a 5% KOH solution with a 10% Glycerol solution to prevent KOH precipitation and extend the slide's life by several hours
☑ Abel's Fluid: 25ml Ethanol 96% + 15ml or 18.9g Glycerol Conc. + 25ml Ammonia Conc. + 35ml Distilled Water ***
☑ 20% Glycerol with 2-4% NaOH in Distilled Water - used as a mounting liquid after staining with Congo Red but not SDS Congo Red
☑ 1% Phloxine - Makes hyphae more visible (This is another red stain). It's also used to see cell contents. Mix 1 drop Phloxine, 1 drop Congo Red, and 1 drop of 3% KOH.
☑ 1% Congo Red (1%) + 1% Boric Acid + 10% Ethanol + 15% Glycerol + Distilled Water - lasts several years
☑ Safranin - Can color nuclei red
☑ 10% Ammonium Hydroxide (NH4OH) with 90% Water ☼ ð - for viewing spore ornamentation, internal structure of spores, some chrysocysitidia, incrusted hyphae 웃
☑ Water with Dilute Glycerol - mounting liquid
☑ Calcofluor White with 10% KOH -
☑ Potassium Hydroxide (KOH) with Chlorazol Black ☠
☑ KOH-DMSO Preparation ☠
☑ Mucicarmine
☑ Periodic acid-Schiff (PAS) and PAS Digest stain
☑ Grocott's Methenamine Silver (GMS) stain
☑ SDS Congo Red - Do not use with KOH. With fresh collections it can show walls and septa. With dried collections it can be used with ammonia or with DWAEG.
☑ Toluidine Blue O - Used for spore wall layers
☑ Trypan Blue
☑ Cresyl Blue - Used for spore wall layers
☑ Ruthenium Red
☑ Patent Blue V - stains deutoroplasm of chrysocystidia, some pigmentations
☑ Congo Red with Ammonia

☑ Sudan III - lipids/resins
☑ Sudan IV - same as Sudan III
☑ Carmine - stains nuclei, siderophilous granules, deuteroplasm of some secretory hyphae and cystidia
☑ Iron-Acetocarmine - Shows nuclei, basidium granules, some siderophilous walls
☑ DWAEG (Partial rehydration - moisture-adding liquid composed of 16ml Distilled Water, 4ml of 25% Ammonia, 80ml of 96% Ethanol, 1g Glycerol). Used for sections but still requires mounting medium.
☑ Carbol Fuchsin
☑ Chloral Hydrate
☑ Chlorovanillin
☑ Acetocarmine
☑ Erthrosin
☑ Fuchsin
☑ Guaiac
☑ Sulphobenzaldehyde (Sulfobenzaldehyde)
☑ Lactophenol Cotton Blue ☠
☑ Lactoglycerol in its place

☠ Caution: Many of these substances are toxic (poisonous) if inhaled, touched, or consumed in any way

*KOH and NaOH can alter the structure of cell walls and may impact microscopy (including swelling, color changes, and even the dissolving of ornamentations)
◊KOH and NaOH can slowly corrode glass dropper bottles over the course of a few months (Replace solutions accordingly)
**Methyl Cellosolve = Ethylene Glycol Monomethyl Ether
***Abel's Fluid can shrink physalohyphae while also making cytoplasm become more granular
☼ Spore color can be altered by Ammonium Hydroxide in some species
ð Some mycologists will use a 3% or 5% Ammonium Hydroxide solution instead of 10%
웃 Ammonia and Ammonium Hydroxide are toxic substances (They should not be exposed to skin (or any part of the body) and they should not be inhaled).

Note: Proper disposal of liquids, glass slides, cover slips, and razor blades is necessary and environmentally intelligent. A "sharps container" can be used for glass and razor blades.

Rehydration Materials

With patience, GSM or Abel's Fluid can be used (See formulas above)
2-10% KOH in H2O (KOH = Potassium Hydroxide). Requires appropriate handling. Safety sheet: http://fscimage.fishersci.com/msds/19431.htm *
10% Ammonium Hydroxide (NH4OH) with 90% H2O
Ethyl Alcohol (=Ethanol) 95-96% (approximately) in 4-5% H2O

Below: Three highly effective liquids to have next to your microscope

Note: 1% or 0.1% Congo Red can be used exactly as it is in order to stain a section. One or two drops, sometimes more depending on the size of a section, is all that's required. Let the stain soak in for 1-4 minutes (depending on the fungi).

Below: A fresh fungal section is performed on a fresh sheet of paper (intentionally away from the slide to prevent contamination or unwanted tissue zones). The desired section is then placed onto a microscope slide. A very small amount of stain is added (1-3 drops usually) with a dropper.

xyz

Below: The excess stain is soaked up with the edge of a napkin or paper towel.

xyz

Below: 3-10% KOH is then added as a mounting (submerging) liquid and a cover slip is added. Any excess KOH/H2O can be soaked up using the edge of a napkin.

xyz

A typical drop bottle of KOH is prepared with approximately 97% distilled water and 3% KOH. Using a 2oz amber bottle, add approximately 1.8 grams of KOH pellets and fill the bottle with distilled water. It can be used to rehydrate, to mount, to "bathe," and in substitute of a stain for a transparent view. Some mycologists prefer 2%-5% solutions and others 10%. Anything above 4% will likely be quite excessive. Note: Thoroughly clean the dropper bottle after a few months and make a new solution. It will get too cloudy if you don't.

Viewing an Unmounted Section

Using the term "unmounted" implies putting a section of fungi directly on a microscope slide and viewing it without anything else. Mycologists use freshly harvest fungi sections for this method. Note that you will not be able to use oil immersion with this method and you may not be able to accurately measure cells. While utilizing this simple method you will see an entirely different world of cystidia, and I can't help but to encourage at least some exploration. Microphotographs are highly encouraged!

Mount VS Crush Mount (Squash Mount)

There are times when cystidia and basidia have to undergo a crush mount in order to see them properly. **ZZZ**

Below: A true gill edge section mounted and viewed without any pressure (measurements of 5 cheilocystidia added).

xyz

Below: The same prepared slide is left on the stage. The objectives are moved so you can maneuver your hand and a pencil over the slide and perform a crush mount.

xyz

One of the methods for squash mounts is to first prepare a gill cross section or preparate cut-out as you normally would (without squashing) and examine the cells. Once familiarity with the section is achieved, flip the scope back to the lowest magnification and crush the sample with a pencil eraser tip while viewing it through the scope. See the effects of the crush as you're performing the squash. This also helps you know where the cheilocystidia and pleurocystidia are so you don't need to make separate mounts.

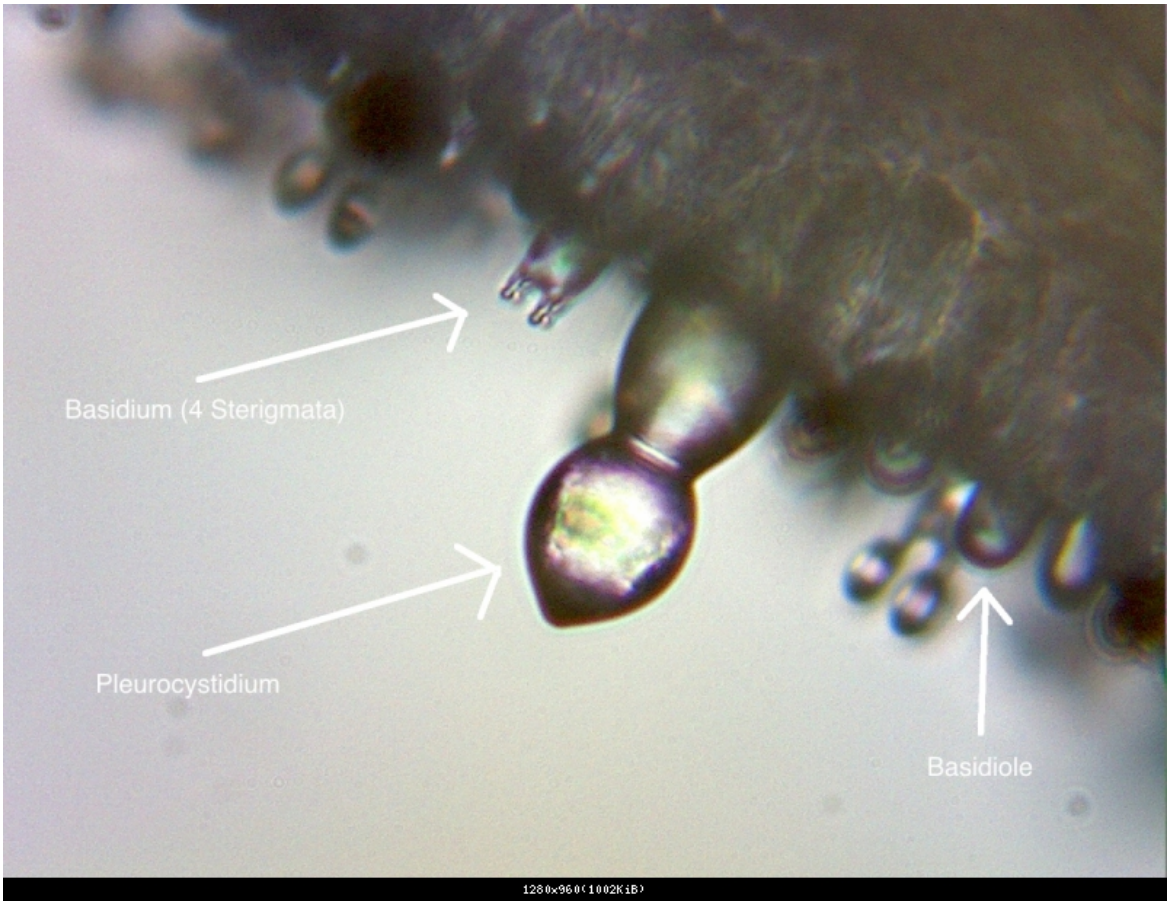
Note: It helps to cover your finger with a kimwipe/tissue/paper towel and press down semi-hard on the cover slip. The squash forces extra water out from under the cover slip and can sometimes rise onto the cover slip.

A Mushroom’s Internal Layers & Outer Surfaces

There are three types of trama (internal layers) and three types of surfaces. We’ll start with the surfaces: Stipe surface, gill surface, and pileus surface. Respectively, these three layers are also called the stipitipellis, the hymenium, and the pileipellis.

Likewise, there are three basic types of internal layers (trama): Stipe (stem) trama, hymenophoral (gill) trama, and pileus (cap) trama.

Basidioles: What They Are And Why They're Overlooked In Identification



Above: An *Agrocybe* species ad int.

More studies need to be done on the form and function of basidioles. We do not know, with certainty, what they are or what purpose they may serve - if any purpose. For decades or longer, basidioles have been considered either immature basidia, aborted (or sterile) basidia, or in a varying developmental stage of basidia (perhaps what one would consider an un-useful mutation that has become a permanent anatomical feature in gilled mushrooms, or similar to a vestige such as the human tail bone or wisdom teeth). In many instances, those new to microscopy inaccurately label these cells as cystidia. Some species do have club-shaped cystidia, resembling closely the shape and size of basidioles.

These cells are abundantly found in many gilled mushrooms. They are located side-by-side with mature basidium on the hymenium surface. They are not currently used in identification, and instead, are overlooked in scientific literature. Although resembling the size and general shape of basidia, they do not have sterigmata (the tips from which spores are powerfully ejected).

Photographing Your Microscope's Images - Without A Digital Imager

You may be able to get better pictures by holding a small digital camera up to the eyepiece instead of using a microscope digital imager. A Canon SD1300 or a Canon Powershot A2300 will work for this. It is good to use a camera that has manual focus.

When making micrographs the focus on the camera doesn't matter as much as the fine focus on the microscope. However, if you have a reticle, the focus on the camera can sometimes make a difference, or else the scale will be blurry. For the SD1300 the scale will come into focus if you set the manual focus to one meter. The A2300 should work fine at the default settings. You may need to adjust the iris diaphragm

on your microscope so there is significantly more light.

Some owners of DSLR digital cameras or bridge cameras can build or order a DSLR microscope adapter similar to these models: http://www.microscopenet.com/digital-microscopes-camera-adapters-c-77_83.html

Final tip: Some people have taken good photos using their cell phones, but this can take patience and coordination.

Keeping The Work Area Orderly

To avoid having spores from one collection end up on a microscope slide for a new collection the workplace must be clean. This includes the mushroom hunting container(s) and the desk surface.

It's a good habit to wipe your desk surface clean with a towel and a little warm water before and after the work day. When working on multiple collections of mushrooms in the same day I add a new sheet of typing paper to work on for each collection.

The collection container is also a concern. Spores will inevitably drop, sometimes in very small quantities, in your compartments. Rinsing the container under the sink with warm water and drying it thoroughly with a sheet or two of paper towel will resolve this.

Also make sure to use a new razor blade each time you switch to a different species of mushroom (and discard the old one). One razor blade is good for a handful of sections before dulling but it can pickup spores easily and these spores end up on a slide as a result.

When the microscope is not in use it should be properly covered to protect the optics from dust, dirt, and airborne particles.

Remember to calibrate your equipment at least once per year. Once per quarter is a much better standard.

Cleaning Microscope Objectives & Eyepieces

These are instructions for basic microscopes in the home. Institutions with microscopes provide specific cleaning instructions for their equipment which should be respected.

Informal Instructions For Cleaning 4x, 10x, And 40x Microscope Objectives

Always follow the exact instructions provided by the microscope manufacturer and/or the institution with whom you are working for. Ideally, *Zeiss Lens Cleaning Wipes* should be a very universal cleaning tissue good for all standard microscope objectives used in compound light microscopes. The aim when using these tissues is to be gentle, be brief, and simply blot the each objective a few times without rubbing or using much pressure.

Alternatively, with some microscopes you can use the tissues that separate microscope slides and a very

tiny amount of an approved objective cleaning liquid. I've personally used Kimtech Kimwipes with a touch of lens cleaner without any issues - but others discourage using kimwipes. It is also possible to use a tiny amount of 70% isopropanol and cotton or kimwipes. Keep in mind that your objectives are expensive and sensitive. You can also get dust off the optics using an air blower like the PISEN Camera Lens Air Dust Blower.

How To Clean The 100x Oil Objective

Clean your 100x oil objective after each use. Use lens paper, clean cotton, or Kimtech Wipes to remove the oil (try and mop it up rather than spread it out). Don't over-do it though as rubbing the objective when it is completely dry might scratch it (even if you are using lens paper). Nothing further is required.

How To Clean The Microscope 10x & 20x Eyepiece(s)

Blow or use an air blower to remove dust before wiping lens
Clean the eyepieces with a cotton swab moistened with 70% ethanol or an approved optical cleaning material
Clean in a circular motion inside out
Wipe the eyepieces dry with lens paper

For more technical methods visit the *Zeiss Clean Microscope* site: http://www.zeiss.com/industry/general_c ... oscope.pdf

Celestron Digital Imager Cleaning Technique

Clean the outside surfaces with slide paper and optic lens cleaner.
Blow off dust with a camel's hair brush or air blower off the optical surfaces.
When cleaning do not rub in circles on this particular imager.

A Very Brief Word About Morphology & Phylogeny

In biology, *morphology* is a branch of bioscience dealing with the study of the form and structure of organisms and their specific structural features. This includes aspects of the outward basidiocarp appearance (shape, structure, color, pattern) as well as the form and structure of internal parts and (microstructures). This is in contrast to physiology, which deals primarily with function. The term is found frequently in scientific papers relating to mushroom identification and should be introduced with microscopy of gilled fungi.

Phylogeny is the study of evolutionary relation among groups of organisms (e.g. species, populations), which is discovered through molecular sequencing data and morphological data matrices. The term phylogenetics derives from the Greek terms phyle (φυλή) and phylon (φῦλον), denoting "tribe" and "race"; and the term genetikos (γενετικός), denoting "relative to birth", from genesis (γένεσις) "origin" and "birth". Phylogeny is important in advanced mushroom identification to understand from what origin "newly" identified species are emerging, as well as the overall relationships between species within the tree of life (Phylogenetic tree).

A Very Brief Word About DNA Sequencing

DNA sequencing is a newer method included in the identification of mushrooms. DNA sequencing is used after (and with) macroscopic and microscopic identification.

Two Methods For Preparing Mushrooms For DNA Sequencing

Method One: Using fresh mushrooms, a section 1cm x 1cm and .5-1mm thick is excised using a flame sterilized scalpel (preferably from an area containing the hymenium). This section is laid onto a Whatman FTA PlantSaver card. The card's plastic reinforced flap is closed on top of the mushroom material, and then this area of the card is tapped with a rubber mallet (or a similar instrument) with moderate force.

Verification that the material was properly squashed in now done by reopening the card and insuring there are liquid contents of the material soaking through the card completely. If not, there may have either been too little material used or not enough mallet force was used - or the material itself may have been too dry. Once a card is properly prepared they are set out to dry on a tabletop or placed in a freezer-quality sealable plastic bag with desiccant. Low humidity must be maintained.

The prepared card is given to a lab with DNA sequencing equipment. The lab will then process (a) portion(s) of the card in 96-well PCR plates, extracting DNA using reagents.

Process described here: http://www.ecbol.org/docs/Publications/ ... _et_al.pdf

A very good PDF on the Whatman FTA Cards: http://www.whatman.com/References/FTA%2 ... 0%20LR.pdf

Another for the plant card: http://www.whatman.com/References/FTA%2 ... 0%20LR.pdf

Whatman FTA PlantSaver cards are expensive. Sharing between mycologists is worth encouraging.

If you can find a better price than: http://www.camlabworld.com/shoppingcart.aspx let me know.

Method Two: Using dried mushrooms (even if they are over 100 years old) a laboratory can go through a few steps to obtain DNA. These instructions are not intended for the average collector to go through but have been published publicly (Molecular Ecology Resources (2010) 10, 628–633) at the following link for reference:

http://www.ecbol.org/docs/Publications/ ... _et_al.pdf

Labs for DNA Sequencing and Other Services

There are mycologists working within labs and universities that may work with you to perform DNA analysis. Here is a brief list of other organizations that perform DNA sequencing of mushrooms at cost that are not university related:

ALVALAB http://www.alvalab.es/

DNA Sequencing & How To Understand Code

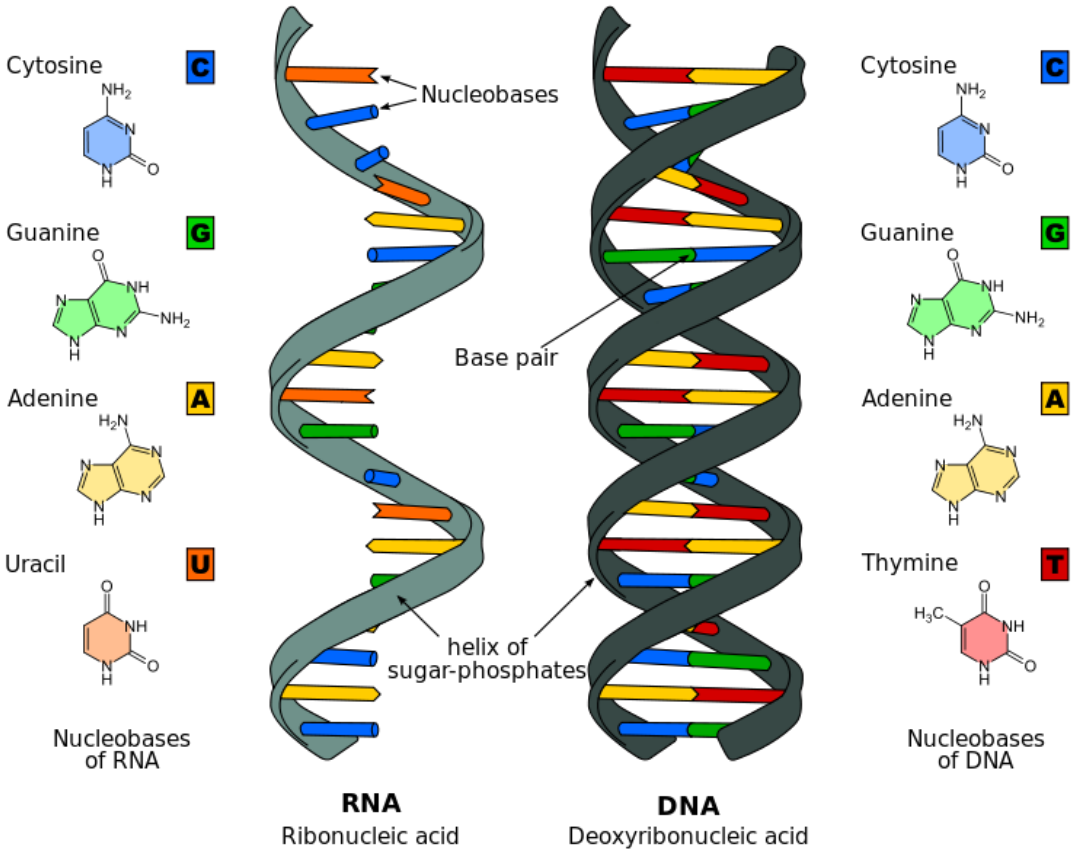
DNA stands for *deoxyribonucleic acid* (or deoxyribonucleic acid molecules). This code, similar to software code, is arranged in letter order, but it only uses 4 basic letters (which are four basic molecules): C (Cytosine), G (Guanine), A (Adenine), and T (Thymine). Again, that code uses the four basic letters CGAT - and those letters (representing the four molecules just mentioned) are arranged uniquely in long sequences for each species of life. These four molecules make up DNA; they are the four basic nucleic acids which make DNA.

Above: *Stropharia rugosoannulata* courtesy Wikimedia Commons

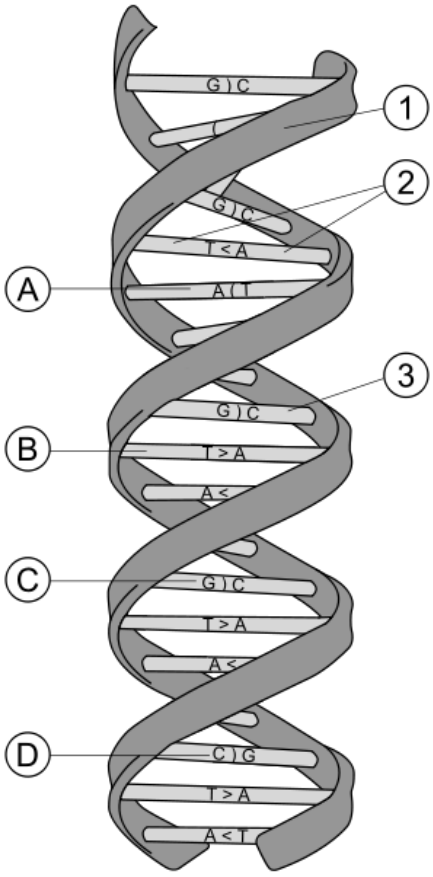
Here's an example of DNA code from *Stropharia rugosoannulata*:

tccgtaggtg aacctgcgga aggatcatta ttgaataaac ctggcttggt tgttgctggt
cttttcggag acatgtgcac gccttgtcat ctttatattt ccacctgtgc acctttttgta
gacttgagga cagatttccg aggcaactcg gtcgtgagga attgctttaa ccggctttcc
ttgaatgtct tcaagcctat gtttcatata caccataaga atgtaacaga atgtcattat
tagacttatg tcttataaac tatatacaac tttcagcaac ggatctcttg gctctcgcat
cgatgaagaa cgcagcgaaa tgcgataagt aatgtgaatt gcagaattca gtgaatcatc
gaatctttga acgcaccttg cgctccttgg tattccgagg agcatgcctg tttgagtgtc
attaaattct caacctttat cagcttttg gttgataaat ggcttggatg tgggagcttg
caggtttctc ttttgaaatc agctctcctg aaatacatta gctggttgcc ttgtgtagac
tagtctatta gtgtgataat tatctacgct gtggactgtt taccgattat agcactgctt
ctaatcgtct gttaactcgg acaatatatg acaatttgac ctcaaatcag gtaggactac
ccgctgaact taagcatatc aataagcgga gga

This (above code) is a small portion of the unique coding order for this particular species. It is how the four nucleic acids are ordered.



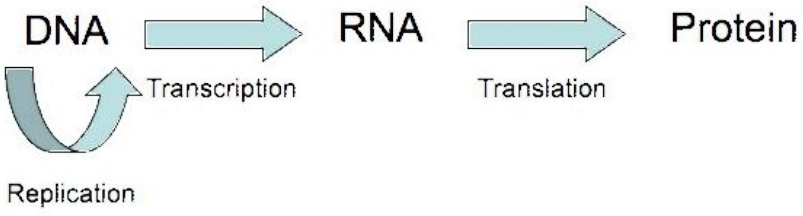
Above: Comparison of a single-stranded RNA and a double-stranded DNA with their corresponding nucleobases (courtesy Wikimedia Commons)



Above: The structure of DNA: A. Adenine B. Thymine C. Guanine D. Cytosine 1. Sugar, Phosphate, Backbone 2. Base pair 3. Nitrogeous base Nucleic acids (courtesy Wikimedia Commons)

Every lifeform, humanity included, is coded by lots of DNA. Instead of working with the entire sequence, scientists (and mycologists) work with specific areas or *regions*. Among the most common regions used in mycology are: ITS1 and ITS2. ITS stand for *internal transcribed spacer*.

If we're going to talk about DNA, we must also take about RNA (ribonucleic acid). It's a nucleic acid present in all living cells. Its principal role is to act as a messenger carrying instructions from DNA for controlling the synthesis of proteins. Above we discussed the 4 letters of DNA (CGAT). RNA is actually one letter different from DNA. The T (Thymine) is not used. In its place is U (Uracil). So, to repeat, that's now **CGAU** instead of the original CGAT.



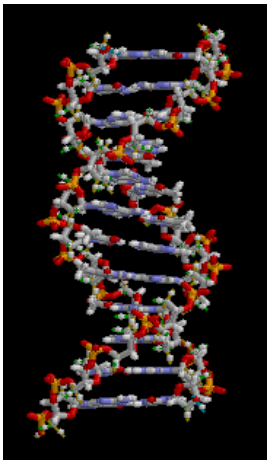
Above: Courtesy Wikimedia Commons

So what is the difference between DNA and RNA?

Both DNA and RNA are composed of repeating units of nucleotides (ie CGAT and CGAU). Each nucleotide consists of a sugar, a phosphate, and a nucleic acid base. The sugar in DNA is deoxyribose. The sugar in

RNA is ribose - the same as deoxyribose but with one more OH (oxygen-hydrogen atom combination called a hydroxyl). This is the biggest difference between DNA and RNA. Another difference is that RNA molecules can have a much greater variety of nucleic acid bases (CGAU and beyond). DNA has mostly just four different bases with a few extra occasionally. The difference in these bases (between DNA and RNA) allows RNA molecules to assume a wide variety of shapes and also many different functions. DNA, on the other hand, serves as a set of directions.

Here's a sample image of DNA:



Above: Courtesy Wikimedia Commons

Do you see how it's kind of shaped similar to a roller coaster? It has a "left" rail and a "right rail" and connection tracks connecting the two rails. The left and right sides are two separate orders of coding (CGAT, etc).

xyz

How do scientists actually perform fungi DNA testing step-by-step?

There are multiple methods. New methods are likely to emerge in the near future. Here's one method: The first step begins with the physical mushroom itself being studied. A *Whatman FTA Card* is used to smash the mushroom and obtain tissue samples. A "punch out" is removed from the card containing the mushroom tissue, and this punch is added to FTA Purification Reagent (to wash it). Afterward it is rinsed in TE-1 buffer. DNA on the washed/rinsed area of the card can now be "amplified" using a PCR (polymerase chain reaction) to replicate (ie create more of) the same target DNA region. PCR is actually three main steps: Denaturation, Annealing, and Elongation.

Once amplified, the DNA is cut at specific locations with a restriction enzyme (this is referred to as "a digest").

ZZZ

Once the sequencing is obtained, it can be "BLAST(ed)" which means "compared" to official databases containing previously saved sequences. BLAST is an abbreviation for "Basic Local Alignment Search Tool." This will provide a comparison to other species and a percentage of similarity to other species. Two blast

sites for this data
are: http://blast.ncbi.nlm.nih.gov/Blast.cgi and http://wasabi.lutzonilab.net/pub/blast/blastUpload (for nucleotide blasts).

FASTA Format

FASTA is a DNA and protein sequence alignment software package first described as FASTP. FASTA is pronounced "fast A", and stands for "FAST-All", because it works with any alphabet, an extension of "FAST-P" (protein) and "FAST-N" (nucleotide) alignment. The FASTA file format used as input for this software is now largely used by other sequence database search tools (such as BLAST) and sequence alignment programs (Clustal, T-Coffee, etc.).

BLAST: Basic Local Alignment Search Tool

The Basic Local Alignment Search Tool finds regions of similarity between sequences. The program compares nucleotide or protein sequences to sequence databases and calculates the statistical significance of matches. BLAST can be used to infer functional and evolutionary relationships between sequences as well as help identify members of gene families. ZZZ

☞ Herbarium Notes: Sending An Undescribed Species To An Herbarium

First, let's discuss what an herbarium is and why they are important. An herbarium receives and stores dried collections of plants and fungi (and in some cases other types of life). Some herbariums specialize only in fungi and will call themselves fungariums. Herbariums are located throughout the entire world, and are very common at reputable colleges and universities. The collections stored in herbariums are often used as reference material in the original and formal description of a species, which is where we get the term "type collection." These collections receive a catalogue number and are used for future research in some instances. In some instances, herbariums will loan collections for such research.

There are four common types of herbarium collections: The holotype collection, the isotype collection, the lectotype collection, and the neotype collection.

Holotype: A single physical example (or illustration) of an organism, known to have been used when the species was formally described.

Isotype: A duplicate specimen of the holotype, collected at the same time by the same person from the same population.

Lectotype: A specimen that is selected from the original material to serve as the type when no holotype was designated at the time of publication or if it was lost or destroyed.

Neotype: Neotype is a specimen derived from a non-original collection that is selected to serve as the type as long as all of the material on which the name was originally based is missing.

The term *type collection*, often found in descriptions, refers to the collection in which a formal description of the species was made. It is the original example which all other collections of the species

are compared to. It is this collection to which the name of a taxon is permanently attached.

In addition to the above types, familiarity with paratypes, epitypes, syntypes, and isosyntypes are needed.

Paratype: In systematic botany, a paratype is defined by the International Code of Botanical Nomenclature (ICBN/ICN) as "a specimen cited in the protologue (i.e., the original description) that is neither the holotype nor an isotype, nor one of the syntypes if two or more specimens were simultaneously designated as types" (Art. 9.5). Under this definition, paratypes are not necessarily explicitly identified as such in the original description. Paratypes are useful in that they allow subsequent botanists to know what collections were examined by the original author and considered part of the same taxon in preparing the description of a new taxon, particularly when the holotype and isotypes may be unavailable, of poor quality, or lacking in certain details. Paratypes are also useful in providing one or more collections from which a lectotype may be designated if no holotype, isotype, syntype, or isosyntype is extant (Art. 9.10).

Epitype: An additional and clarifying type could be designated, an *epitype* under §9.7 of the Vienna Code, where the original material is demonstrably ambiguous or insufficient.

Syntype: In botanical nomenclature, a syntype is defined as "any specimen cited in the protologue when there is no holotype, or any one of two or more specimens simultaneously designated as types." (Art. 9.4 of the 2006 botanical Code).

Isosyntype: Isosyntypes are duplicates of a syntype.

Sending A Collection To An Herbarium

The 1958 Mycologia Issue (Volume 50 Page 442) shows an older method for sending gilled mushrooms to an herbarium. The method at that time was to place each individual, fully dried mushroom into a fitting envelope and glue the envelope(s) to 11x17 herbarium mounting paper, and label them. The other method mentioned in this same article shows that most herbariums were taking deposits that were first fully dried and then placed into labeled boxes.

A better method is to fully dry the mushrooms at 105 degrees and then place them into ziplock bags. The bags are then placed into a small box for extra protection. The box is labelled appropriately and each bag gets a label inserted into it as well. The ziplocs keep out air and pathogens.

A good collection for one herbarium will be 15 specimens in ideal condition, although sometimes this will simply not be possible. The collection should represent as much diversity of the species, including very young mushrooms, middle aged mushrooms, and fully adult mushrooms - but avoid decaying ones if possible. Include the entire mushroom, including the base of it (you can pull very gently and wiggle it free from the ground to do this, or use a knife to dig into the earth and push the mushroom up). A portion of the mycelium is also helpful and should be included if nature allows.

If the mushroom is parasitic also collect some of the host.

Photograph your collection as thoroughly as possible and post these images on a site of your choosing, such as MushroomObserver. Include the link for the herbarium. Lastly, make any helpful notes and include them in the online images or in a letter with the collection. An example of the items that should be listed: Genus and species (if known), collector name, date collected, habitat, associated plant life or trees, location (city, state, and grid coordinates), Google Earth altitude, and any additional features of the mushroom that could be overlooked in the photography.

The collection must go to an internationally accessible herbarium dealing with fungi. Email the curator or collections manager in advance to confirm they are willing to receive it and process it! If multiple collections of the same species can be made available, they should be distributed to other nations. For international mailing, on the customs form write “dried herbarium specimens” and inside label it with an observation number and/or the species epithet.

Joining Macroscopic Observations With Microscopic Observations

Every mycologist should attempt to capture the following photographs when describing a species or when posting thorough observations:

Below: Natural image of mushrooms untouched from a distance (In situ) (*Psilocybe stuntzii*)

Below: Natural image (in situ) of mushrooms untouched up close (from the genus *Coprinellus*)

Below: Laid down in order of maturity (*Psathyrella* species)

Below: *Bertrandia astatogala* with ruler (in millimeters) courtesy Mike Wallace

Below: Pileus up close (An *Inocybe sororia* specimen)

Below: Cap margin zoom (*Stropharia ambigua*)

Below: Gills up close (*Stropharia ambigua*)

Below: Stipe up close (*Laccaria amethysteo-occidentalis*)

Below: Base of stipe(s) up close (*Inocybe calamistrata*)

Below: If present, show the annulus or annular zone up close

xyz

Below: If present, show the partial veil up close while still attached to the pileus as seen in this image of an *Agaricus augustus* partial veil captured by Mycologist Alan Rockefeller

Below: Mushroom neatly cut in half from top to bottom

xyz

Below: Zoom on substrate (*Psilocybe stuntzii* in mulch)

Below: Pileus and stipe tested with 5% or 10% KOH and photographed soon after. (If KOH is unavailable and/or a natural color change occurs, an image should be taken). (*Armillaria*sp.)

Below: Image(s) of associated or nearby plants (including trees), lichens, or other life (*Psilocybe zapotecorum* habitat courtesy Alan Rockefeller, MushroomObserver No. 212615)

Below: A couple of good looking specimens fully dried with a mm ruler

xyz

Below: A color change on the stipe or cap can occur in some collections from simply touching the mushrooms. Before and after photos, side-by-side, are helpful.

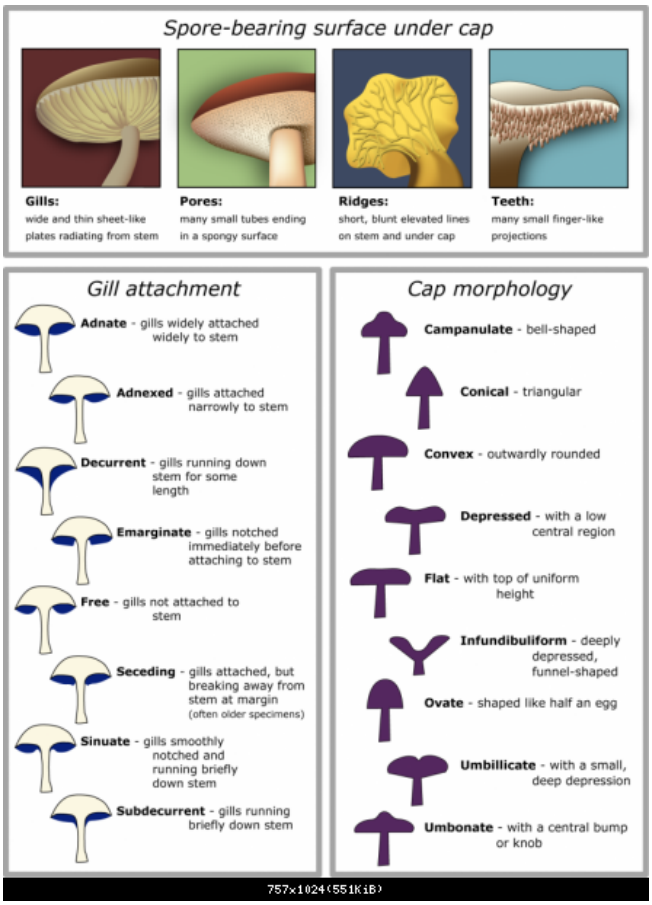
xyz

Below: Below surface primordia of *Agrocybe praecox* (sensu lato) uprooted accidentally by slowly wiggling an "adult" specimen from the ground. In some species primordia will grow above ground, but slow-harvesting a mushroom will occasionally reveal primordia attached to the base of the stipe.

Below: A *Gymnopilus dilepsis* spore print is taken on tin foil to observe its color to assist in identification

These photos, combined with micrographs and notes, will provide mycologists and students with a valuable dataset of identifying features.

Macroscopic Characters with Taxonomic Value

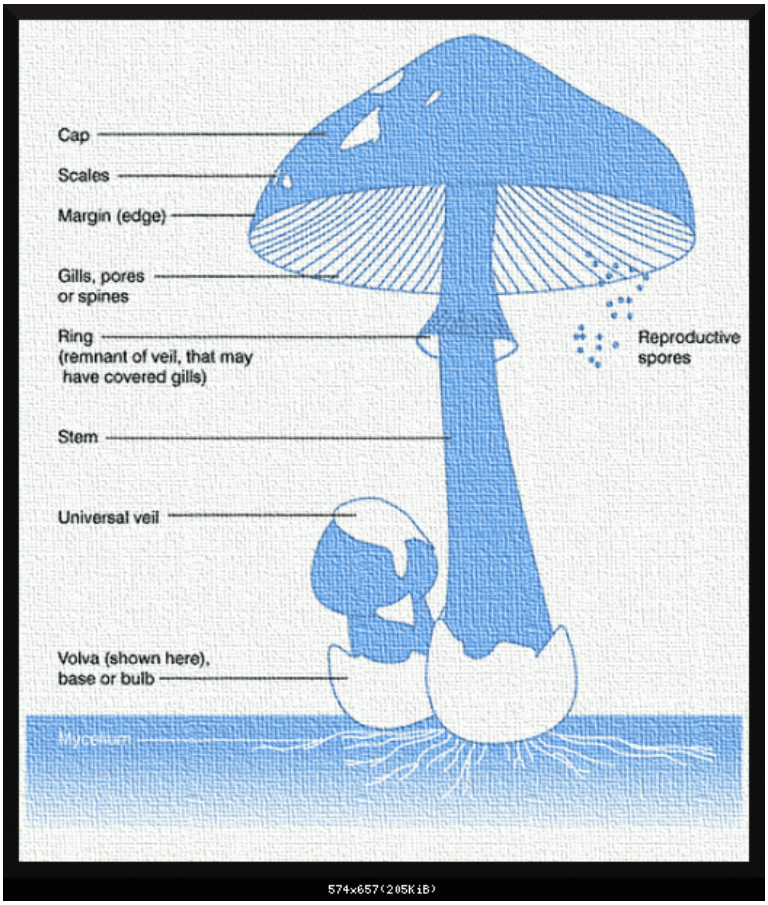


Above: Image courtesy Wikimedia Commons

The form, size, and color of the pileus
Viscid or dry pileus
Hygrophanous or non-hygrophanous pileus
Even or striate pileus
Glabrous or scaly pileus
Presence of a gelatinous pellicle
Position of the gills
Color of the gills
Gill distance between one another
Spore print color
Development of the veil or cortina
Presence or absence of annulus
Size, color, and surface of the stipe
Stipe is solid, stuffed (with hyphae), hollow, fistulose, broadly fistulose, or chambered (sensu Vellinga et al. in Flora Agaricina Neerlandica)
Presence of rhizomorphs and pseudorhiza
Base of stipe (shape, color, size, attachment, presence or obsence of a basal stipe disc)
Consistency in pattern and appearance of the stipe

Overall growth stages (young to adult) of species
The presence or absence of lactiferous fluid
Habitat & Ecology
Distribution (The geographical area(s) in which a species can be found)
Presence or absence of sclerotia
Growth pattern (gregarious, etc)
Field chemical reaction test (KOH, etc)
In some instances the aroma and flavor of the mushroom can provide identification help
Deliquesence

Below: A diagram of the parts of some gilled mushrooms (redrawn from http://www.mushroomdiary.co.uk)



Below: A *Gymnopilus aeruginosus* sensu amplo spore print is taken for roughly 4 hours on tinfoil to determine the color courtesy Caleb Brown

Microscopic Characters with Taxonomic Value

A thorough observation of spores will include the following: Size, shape, wall thickness, color, ornamentation, the presence or absence of a germ pore, symmetry, attachment, the presence or absences of a membrane (perispore), a spore pigmentation test, and spore inner contents
The presence (or absence) and measurement of cheilocystidia including shape, color, ornamentation, crystals present/absent, encrustation, wall thickness, variation between individual cystidia, and contents
The presence (or absence) and measurement of pleurocystidia including shape, color, ornamentation, crystals present/absent, encrustation, wall thickness, variation between individual cystidia, and contents
The size and variation in appearance of basidia, including the amount of sterigmata
Gill trama pattern
The type of subhymenium (*Note: Some mycologists do not use this as a taxonomic feature)
Pileus trama pattern
Pileus pileipellis pattern
Stipe trama
Stipitipellis form
The presence, form, and measurement of other types of cystidia (pileus cystidia, caulocystidia, chrysocystidia, mycelial cystidia, brachycystidia, etc) - or the absence of these cells
Mycelial conidia (Often requiring separate isolation work on agar)
Sclerotia layers and appearance of their hyphae
Cell chemical reaction test (KOH, Lugol's, Sulfuric Acid, etc)
The presence or absence of clamp connections

Macroscopic Chemical Reaction Tests in Mushroom Identification

Some mushroom photographers perform a very fast and simple reaction test by bringing along a 2oz dropper bottle of 3-10% KOH. Some mycologists even use a variety of different chemicals. Usually this will bring about either a "negative" (no result) or a color change of some kind. It only takes 1 to a few minutes for the reaction to occur. It should be noted and photographed.

Above: *Agaricus pocillator* experiences a color change with KOH dripped onto its pilei. (Photo credit: A. Rockefeller)

Moving Beyond KOH in the Field

Household Ammonia - dropped on macroscopic material for possible color change

2-3% Phenol - Dropped on macroscopic material for possible color change to pileus or stipe

Guaiac - Test for the presence of phenol-oxidase enzymes in mycelium

10% Iron Salts in Distilled Water (Synonyms Iron Sulfate, $FeSO_4$, Iron(II) Sulfate, Ferrous Sulfate, Copperas, Green Vitriol) - Dropped on macroscopic material for possible color change

Sulfovanillin (Sulphovanillin, Sulpho-Vanillin) - Made from sulfuric acid (H_2SO_4) and vanillin (vanilla). Used in Russula identification and microscopically for viewing sulphidia in some Panaeolus species.

PDAB - Composed of PDAB dissolved in solution of conc. HCl acid and 95% ethyl alcohol. In the genus

Lyophyllum the lamellae usually turn blue when PDAB is added

Chemosystematics: Chemical Characters with Taxonomic Value

The presence or absence of psilocybin, psilocin, baeocsytin, nor-baeocystin (i.e. norbaeocystin, neobaeocystin), or aeruginascin based on HPLC, TLC, MS-GC analysis or similar methods. See Andersson et al., 2008.

The presence or absence of muscarine. See Kosentka P, Sprague SL, Ryberg M, Gartz J, May AL, et al. (2013).

The presence or absence of muscimol, ibotenic acid, antamanide, amatoxins, phallotoxins, α-amanitin, ß-amanitin, phallolysin, virotoxins, and **xyz**.

The DNA sequence relevant to the area or production area of a chemical. (e.g. A supplementary DNA barcode zone).

The variance of a chemical's quantity within a mushroom's anatomical locations, and the variance of a chemical's quantity in different collections, different seasons, and different geographical locations).

ZZZ

DNA Characters with Taxonomic Value

A complete ITS region (official barcode) sequence obtained using a repetitive, accurate method.

An entire genome sequence used in current and future comparisons to other species.

Additional regions for comparative studies including CO1, COX1, EF1 Alpha, RPB1, RPB1-intron 2, RPB2, 18S, 25S, Small Subunit ribosomal RNA, and Large Subunit ribosomal RNA, etc.

A complete genome sequence of a mushroom's sub-surface mycelium. (See *Identification of Mushroom Mycelia Using DNA Techniques*, Muruke, et al.).

All collected sequences obtained from the substrate(s) harvested with the basal mycelium of fruit bodies (i.e. non-fungal and co-existing fungal sequences).

*Awaiting consensus-driven, supported literature to discuss error margins, missing base pairs allowance/disallowance, minimum base pair comparison, how many sequences of each species are necessary for knowledge of its variation range.

**Additional DNA “characters” will be valuable in taxonomy in the future (ie supplementary barcodes).

Mating Compatibility Studies w/Taxonomic Value

Agar-filled petri dishes showing compatibility or incompatability between species can be determined (with exception) with non-wild type data.

Mating type (MAT) locus sequence.

Quantity of mating types.

*Awaiting consensus-driven, supported methods (mating studies are often considered invalid).

Comparative Studies w/Taxonomic Value

Comparison of all macroscopic, microscopic, chemical, DNA, and mating compatibility studies within the genus.

This six-point system comprised of macroscopic, microscopic, chemosystematic, DNA, mating compatibility, and comparative analysis could be further developed and likely fulfills a stronger basis for modern day Psilocybe species identification. These criteria should be considered for standardization in taxonomy and provided when species description publication occurs. This approach attempts to merge the biological species concept to other important species concepts, including DNA barcode comparison at the base pair level.

In addition to this six-point system, anthropological studies (more precisely, *ethnomycological studies*) should be included whenever possible, although most species with be lacking in this subject. Ethnomycology is the study of the historical uses and sociological impact of mushrooms. Although in theory the term includes fungi used for such purposes as tinder, medicine (medicinal mushrooms) and food (including yeast), it is often used in the context of the study of psychoactive mushrooms such as psilocybin-containing mushrooms, ergot and *Amanita muscaria*.

Aroma and Flavor in the Field

A disclaimer/word of caution first: Never eat an unidentified or inedible mushroom. The following methods are used by mycologists to further the identification process before microscopy. The first thing that can be done after photography is an aroma test. Smell the mushroom as it is - without any other effort. Then, if extra specimens are available, "rub" a mushroom pileus and stem a few times and do another smell. Note these aromas in your observation because they can help others during the identification process. The next thing you can do is similar. It does not imply that you eat (chew and swallow) any material. It does mean you'll nibble off a very small piece, and briefly try to get a flavor description (all of the material that was nibbled is then spit out).

How Can I Find Out If I've Collected An Undescribed Species?

Photograph the collection thoroughly, perform basic and advanced microscopy and include those photos in a "new observation" thru MushroomObserver.org, then dry and store your collection with the MO observation number. Through peer review sites like Mushroom Observer and others, the mushroom will usually receive a proposed genus to consider. At this point you can key out your mushroom and see if it is analogous to any species in the genus. It may be helpful to use a dedicated book on the genus as well. There are monographs (keys) with very detailed descriptions of both common and rare species in specific genera. A good source for these books, beyond that of typical online stores, is: http://www.nhbs.com/index.php?ad_id=1443. If no peer review sites confidently select a species, and

none of the keys you've used point to an accurate description, it is time to ask a qualified expert (usually an author of the most informative key) in the proposed genus. You can, simultaneously, take the independent route of having the material sequenced and blasted for DNA comparison.

Keys To Microscopic and Macroscopic Identification

There are many (probably several hundred) "keys" to identify mushrooms based on a variety of approaches and methods. Probably the best resource as of 2013 is the work of Mycologist Michael Kuo through his online (and ongoing work) http://mushroomexpert.com/major_groups.html

Other Keys...

http://nature.berkeley.edu/brunslab/pmb ... Keys-49575
http://www.mushroomexpert.com/agaricales.html
http://www.rogersmushrooms.com/gallery/chooser.asp
http://www.svims.ca/council/keys.htm
http://www.svims.ca/council/Key_to.htm
http://www.britmycolsoc.org.uk/library/keys/
http://www.britmycolsoc.org.uk/files/57 ... oletes.pdf
http://forestry-dev.org/cgi-bin/matchma ... hMaker.asp
http://www.mykoweb.com/CAF/skey/agaric.html
http://www.euromould.org/links/keys.htm
http://www.mycokey.org/agaric1.shtml?la ... 2056576759
http://www.mycokey.org/MycoKeySearchUK. ... mode=false
http://www.fungaljungal.org/key/step3.html

Keys by Family (With Selected Species Keys)

■ ***Agaricaceae***

Agaricus

http://www.mushroomexpert.com/agaricus_01.html
http://www.svims.ca/council/Agari1.htm

Chlorophyllum

http://nature.berkeley.edu/brunslab/ev/ ... HYLLUM.pdf

Coprinus

http://www.svims.ca/council/Coprin.htm#nCop
http://www.mushroomexpert.com/coprinoid.html
http://www.grzyby.pl/coprinus-site-Kees ... prinus.htm

Lepiota

http://www.svims.ca/council/Lepiot.htm

Leucoagaricus

http://www.svims.ca/council/Lepiot.htm

Leucocoprinus

http://www.svims.ca/council/Lepiot.htm

Macrolepiota

http://www.svims.ca/council/Lepiot.htm

Panaeolopsis

zzz

▉ *Amanitaceae*

Amanita

http://www.amanitaceae.org/?Keys%20-%20 ... e%20Groups
http://www.svims.ca/council/Amanit.htm
http://pluto.njcc.com/~ret/amanita/key.dir/pnwcakey.pdf
http://www.mycokey.com/newMycoKeySite/F ... manita.pdf
http://www.mushroomexpert.com/amanita.html
http://www.fungaldiversity.org/fdp/sfdp/32-7.pdf

▉ *Bolbitiaceae*

Bolbitius

http://www.mycosphere.org/pdfs/MC4_6_No3.pdf

Conocybe

http://www.ut.ee/ial5/fce/fce45pdf/fce45_hausknecht.pdf

Copelandia

zzz

Panaeolina

http://www.britmycolsoc.org.uk/files/57 ... oletes.pdf

Pholiotina

http://www.ut.ee/ial5/fce/fce45pdf/fce45_hausknecht.pdf

■ *Cortinariaceae*

Cortinarius

http://www.australasianmycology.com/pag ... /3/173.pdf
http://nature.berkeley.edu/brunslab/pmb ... caceae.pdf
https://www.doria.fi/bitstream/handle/1 ... rtinar.pdf (Cortinarius subgenus Telamonia)

Type Species: *Cortinarius violaceus* (Type Collection Location:)

xyz

Above: *Cortinarius violaceus* (L.: Fr.) Gray

Crepidotus

http://quod.lib.umich.edu/f/fung1tc/AGK ... =monograph
http://www.mykoweb.com/Crepidotus/index.html

Cystolepiota

http://nature.berkeley.edu/brunslab/ev/ ... ep_key.pdf
http://www.svims.ca/council/Lepiot.htm

■ *Entolomataceae*

Entoloma

http://www.entoloma.nl/pdf/key_entoloma_tasmania.pdf
http://www.entoloma.nl/pdf/enttas2.pdf

■ *Gloeophyllaceae*

Gloeophyllum

http://www.svims.ca/council/Polypo.htm

■ *Gomphidiaceae*

Chroogomphus

http://www.svims.ca/council/Gomphi.htm
http://www.mycologia.org/content/95/1/176/F1.large.jpg

■ *Hydnangiaceae*

Laccaria

http://ia700307.us.archive.org/19/items ... 30muel.pdf

■ *Hygrophoraceae*

Ampulloclitocybe

http://www.mykoweb.com/CAF/keys/Clitocybe_key.pdf

Camarophyllus

zzz

Chromosera

zzz

Gliophorus

zzz

Hygrocybe

http://www.somerc.com/uploads/waxcap_id ... _guide.pdf
This begins a download of the PDF and it will give a warning first: sxbrc.org.uk/file_download/2

Hygrophorus

http://ia601507.us.archive.org/25/items ... 00hesl.pdf
http://quod.lib.umich.edu/f/fung1tc/ajn ... =monograph

Humidicutis

zzz

■ *Hygrophoropsidaceae*

Hygrophoropsis

http://boletales.com/genera/hygrophoropsis/

▉ *Hymenogastraceae*

Galerina

http://quod.lib.umich.edu/f/fung1tc/agk ... ge&size=75
http://www5.uhh.hawaii.edu/~baperry/Key ... a_key.html

Hebeloma

http://quod.lib.umich.edu/f/fung1tc/AAW ... stropharia

Phaeocollybia

zzz

▉ *Inocybaceae*

Inocybe

http://www.mushroomexpert.com/inocybe.html
http://www.mykoweb.com/CAF/keys/PNW_Inocybe_key.pdf
http://www.svims.ca/council/Inocyb.htm

▉ *Lyophyllaceae*

Lyophyllum

http://www.svims.ca/council/Lyophy.htm

▉ *Marasmiaceae*

Gymnopus

http://caps.ceris.purdue.edu/webfm_send/253
http://www.nybg.org/bsci/res/col/sectkey.html

Marasmius

http://caps.ceris.purdue.edu/webfm_send/253

Rhodocollybia

http://www.nybg.org/bsci/res/col/rhodo.html

▉ *Mycenaceae*

Hemimycena

http://prfdec.natur.cuni.cz/cvsm/CM61103.pdf
http://www.entoloma.nl/html/hemimycenae ... #DEFINITIE

Mycena

http://www.mushroomexpert.com/mycenoid.html
http://mycena.no/key1.htm
http://www.svims.ca/council/Myceno.htm#nMar
http://quod.lib.umich.edu/f/fung1tc/agk ... =monograph
http://home.online.no/~araronse/Mycenakey/key1.htm
http://home.online.no/~araronse/Mycenak ... s_sect.htm

Panellus

http://www.mushroomthejournal.com/great ... us114.html

Xeromphalina

http://www.svims.ca/council/Xeromp.htm

Omphalotus

zzz

▉ *Omphalotaceae*

Lentinula

zzz

▉ *Paxillacea*

zzz

▉ *Physalacriaceae*

Armillaria

http://botit.botany.wisc.edu/toms_fungi/armkey.html
http://en.wikipedia.org/wiki/List_of_Ar ... pecies#Key

Flammulina

http://www.bio.utk.edu/mycology/Flammul ... t.html#KEY TO THE TAXA OF FLAMMULINA

Oudemansiella

zzz

■ ***Pleurotaceae***

Pleurotus

http://www.bio.utk.edu/mycology/Pleurotus/key.htm

■ ***Psathyrellaceae***

Coprinellus

http://www.mushroomexpert.com/coprinoid.html

Coprinopsis

http://www.svims.ca/council/Coprin.htm
http://www.mushroomexpert.com/coprinoid.html

Lacrymaria

zzz

Panaeolus

http://www.svims.ca/council/Panaeo.htm
http://www.mushroomexpert.com/olah_panaeolus_key.pdf

Parasola

http://www.mushroomexpert.com/coprinoid.html
http://www.svims.ca/council/Coprin.htm

Psathyrella

http://quod.lib.umich.edu/cgi/t/text/te ... 4.0001.001

▉ *Repetobasidiaceae*

Contumyces

zzz

▉ *Russulaceae*

Lactarius

http://quod.lib.umich.edu/f/fung1tc/AAC ... stropharia

Russula

http://www.mushroomexpert.com/russula.html
http://www.svims.ca/council/Russul.htm
http://ucanr.edu/sites/PLPMikeDavisLab/ ... ation_Key/

Sarcodon

http://www.svims.ca/council/Sarcod.htm
http://www.fieldmycology.net/GBCHKLST/key.asp?KeyID=5

■ *Schizophyllaceae*

Schizophyllum

http://www.svims.ca/council/Key_to.htm

■ *Strophariaceae*

Agrocybe

http://www.svims.ca/council/Agrocy.htm

Bogbodia

zzz

Deconica
http://www.entoloma.nl/html/psilocybeeng.html#tabel

Gymnopilus

http://www.svims.ca/council/Gymnop.htm

Hypholoma

http://www.mushroomexpert.com/hypholoma.html
http://www.jstor.org/stable/40594043

Kuehneromyces

http://www.svims.ca/council/Pholio.htm

Pholiota

http://www.mykoweb.com/Pholiota/North_A ... oliota.pdf
http://www.svims.ca/council/Pholio.htm
http://www.mykoweb.com/Pholiota/index.html

Psilocybe

http://www.svims.ca/council/Stroph.htm#nPsi

Stropharia

http://www.fungaldiversity.org/fdp/sfdp/32-3.pdf

http://www.jstor.org/stable/10.2307/40594155

■ *Tricholomataceae*

Callistosporium

http://www.zobodat.at/pdf/Sydowia_35_0223-0235.pdf

Clitocybe

http://www.mykoweb.com/CAF/keys/Clitocybe_key.pdf

Collybia

http://caps.ceris.purdue.edu/webfm_send/253
http://www.nybg.org/bsci/res/col/collsp.html

Resupinatus

http://www.funnz.org.nz/sites/default/f ... atus_4.pdf

Tricholoma

http://www.svims.ca/council/Tricha.htm

Tricholomopsis

http://www.svims.ca/council/Tricho.htm

■ ***Tubariaceae***

Tubaria

■ ***Unknown Family***

Hemistropharia

zzz

Mushroom Identification Keys & Building New Keys

The following links may prove helpful in designing new identification keys:

http://www.identificationkey.fr/ikeyplus/
http://mrfaught.weebly.com/uploads/2/3/ ... e-home.pdf

The first mushroom identification key you will read will likely be a trial of patience and perseverance. Hopefully you'll be using keys and remembering what you would have done to make the information easier to process. This is another task of today's mycology students and mycophiles.

There are a number of books available but there are now many online and free keys to use. Perhaps http://www.mushroomexpert.com by Michael Kuo is the very best one for those living in the U.S. In the meantime, there is a very obvious need for better keys to be developed across the planet so identification can be done from multiple approaches and with more precision. Additional apps should be designed to build new dichotomous identification keys for fungi.

Mushroom Taxonomy at Mushroom Fairs & Festivals

To have an official mushroom fair (festival), there is a fundamental need to add mushroom hunting and identification into the mix.

Above: An artist's handmade billboard inviting folks to the festival in Michoacan, Mexico. Courtesy Alan Rockefeller.

Tables are setup and people bring their collections for identification with fellow mycophiles.

Clear plastic display label holders can optionally be added for aesthetics.

Each person who wants to contribute can take wicker baskets (or several other types of containers) and gather local mushrooms fresh from the field (whether they are found in the location of the festival or several miles away).

Every mushroom festival deserves a presentor with a laid back presentation (or multiple presentations).

A casual and inexpensive microscope desk is setup for viewing spores and other cell types (courtesy Mycologist Alan Rockefeller).

Each collector can fill out a really fast mini-sheet that will help others identify the fungi in question.

xyz

At least one microscope is setup on a table for public observation of a gill cross section so spores and cystidia can be observed.

Above: Members of the North East Fungus Study Group of the United Kingdom explore the microscopic dimension of identification (Photo credit: Paul Forster). This gathering allowed members to link up at a local university's biology lab.

The community works together with online or in-print identification keys to label each collection with a proposed genus and species name.

Above: Members of the North East Fungus Study Group of the United Kingdom in the process of identification (courtesy John Robinson of the microscopy shoppe Micro-Science).

Recommended Herbariums

University of Washington Herbarium (WTU) (http://www.burkemuseum.org/herbarium/)

"The University of Washington Herbarium (also known as WTU) is an international resource for research into the diversity, distribution and ecology of Pacific Northwest vascular plants, non-vascular plants, fungi, lichen, and algae. With over 600,000 specimens currently in the collections and between 5,000-10,000 specimens added annually, WTU is one of the largest herbaria in the region. A history of WTU can be found here. The Herbarium has an active loan and exchange program, and is open to the public. For information about loans or visiting WTU, contact the Collections Manager. Support from the National Science Foundation's Biological Research Collections program (2003-2007) led to our databasing over 120,00 Pacific Northwest vascular plant specimens, which are available through our online database. This funding also supported creation of the Consortium of Pacific Northwest Herbaria website, which provides access to specimen data and digital resources from throughout the region." - Taken from WTU site

University of British Columbia, Vancouver, BC, Canada
(UBC) http://www.biodiversity.ubc.ca/museum/herbarium/

Mycological Department, National Museum, Prague, Czech Republic (PRM) http://www.nm.cz/Natural-History-Museum ... Agaricales

San Francisco State University, San Francisco, CA, USA
(SFSU) http://userwww.sfsu.edu/patters/herbarium/

University of Michigan Herbarium (MICH) http://herbarium.lsa.umich.edu/

Royal Botanical Gardens, KEW http://www.kew.org/collections/fungi.html

The Evergreen State College, (EVE). Herbarium The Evergreen State College 2700 Evergreen Parkway NW Olympia, WA 98505

For a searchable list of herbariums (herbaria) throughout the globe please reference: http://sweetgum.nybg.org/ih/ihmapsearch.php

Other Sites

Nomenclature Committee for Fungi

http://www.ima-mycology.org/CFF/

A permanent Nomenclature Committee for Fungi is installed by the Nomenclature Section of the International Botanical Congress. Its task is to discuss and vote on proposals concerning conservation & rejection of fungal names, as well as consider proposals to modify the International Code of Nomenclature for algae, fungi, and plants with respect to fungal names.

The Nomenclature Committee for Fungi (NCF) has at present 18 members. Those with nomenclatural problems are encouraged to contact the members for advice. If you find any particular fungal name that requires protection, it is recommended that you publish a proposal either to conserve that name or to reject an undesirable name, possibly in collaboration with a member of the committee. All current proposal PDFs can be downloaded at no cost from http://www.ingentaconnect.com/content/iapt/tax

EOL - (Encyclopedia of Life) http://eol.org/about and http://eol.org/info/mushrooms?language=en

"The Encyclopedia of Life Learning + Education Group introduces undergraduate biology instructors to a new set of tools that enable students to research and publish species accounts to the Encyclopedia of Life (http://www.eol.org).

The EOL Learning + Education Group, based at Harvard University's Museum of Comparative Zoology, works in collaboration with three partners (Animal Diversity Web, AmphibiaWeb and Mushroom Observer) who provide online collaborative tools to facilitate the writing of species accounts by undergraduate biology students for specific taxonomic groups. EOL's Education LifeDesk is another species page authoring tool suitable for any taxonomic group. The opportunity to research and publish these accounts to the Encyclopedia of Life is a challenge that many students find highly motivating and rewarding." - (EOL, 2013)

MycoBank http://www.mycobank.org/

MycoBank is an on-line database aimed as a service to the mycological and scientific society by documenting mycological nomenclatural novelties (new names and combinations) and associated data, for

example descriptions and illustrations. The nomenclatural novelties will each be allocated a unique MycoBank number that can be cited in the publication where the nomenclatural novelty is introduced. These numbers will also be used by the nomenclatural database Index Fungorum, with which MycoBank is associated.

Nomenclatural experts will be available to check the validity, legitimacy and linguistic correctness of the proposed names in order to avoid nomenclatural errors; however, no censorship whatsoever, (nomenclatural or taxonomic) will be exerted by MycoBank. Deposited names will remain -when desired- strictly confidential until after publication, and will then be accessible through MycoBank, Index Fungorum, GBIF and other international biodiversity initiatives, where they will further be linked to other databases to realize a species bank that eventually will link all databases of life. MycoBank will (when applicable) provide onward links to other databases containing, for example, living cultures, DNA data, reference specimens and pleomorphic names linked to the same holomorph. Authors intending to publish nomenclatural novelties are encouraged to contribute to this new initiative.

Pairwise sequence alignments and polyphasic identifications of fungi and yeasts against curated references databases are proposed.

North American Mycoflora Project http://www.northamericanmycoflora.org/index.html

"The long-term goal of this project is to produce a modern, comprehensive mycoflora of macrofungi for North America. This would be a resource that contains monographic treatments of all the macrofungi. It would provide online keys and downloadable applications, up to date distribution maps, links to macroscopic and microscopic images, and links to nucleotide sequences and phylogenetic trees. We are a long way from this goal and will need the help of everyone interested in this project to get there." - (North American Mycoflora Project, 2013)

Index Fungoram http://www.indexfungorum.org/

"The Index Fungorum, the global fungal nomenclator coordinated and supported by the Index Fungorum Partnership (CABI, CBS, Landcare Research-NZ), contains names of fungi (including yeasts, lichens, chromistan fungal analogues, protozoan fungal analogues and fossil forms) at all ranks. Funding from GBIF (2003-2004) under the ECAT work programme enabled the addition of most missing author citations and year of publication and the linking of most homotypic names. This work continues and it is anticipated to be complete by the end of 2012. New names from the Index of Fungi, compiled at CABI-UK and published by CABI, are added every three months. In addition, names deposited with MycoBank are incorporated in Index Fungorum as they are released. Further, in anticipation of changes to the next edition of the ICN relating to registration of names and following the lead taken by MycoBank, Index Fungorum now provides a mechanism to register names of new taxa, new names and new combinations at — no login is required, a captcha effectively excludes spammers.

Species Fungorum is currently a CABI-UK coordinated initiative to compile a global checklist of the fungi. You may search a small but growing number of taxonomically complete datasets - global species databases - or the entire Species Fungorum. Species Fungorum contributes the fungal component to the Species 2000 project and, in partnership with ITIS, to the Catalogue of Life (currently used in the GBIF and EoL portal); for more information regarding these global initiative visit their websites. Please contact

Paul Kirk if you you would like to contribute to Species Fungorum.

The Dictionary of the Fungi (currently 10th edition, 2008) published by CABI also contains the current consensus on the fungal taxonomic hierarchy to the rank of genus. You can search the database for the status of generic names, or walk down the hierarchy from the rank of Kingdom. The entries for each genus generally include authors and place of publication together with the type species (linked to Index Fungorum) and other data.

The Bibliography of Systematic Mycology, compiled at CABI-UK and published by CABI, provides a survey of the literature encompassing the biodiversity, classification, distribution, evolution, identification, nomenclature, phylogeny, systematics and taxonomy of fungi (as defined in the first paragraph). You can search the database using the index of cited generic names or author names.

All these databases need to be improved and updated in terms of data content. Please contact Paul Kirk if you have any additions or suggested changes (which will be acknowledged). The database structures have been developed by Jerry Cooper and Paul Kirk and the web interface by Jerry Cooper. Please contact Paul Kirk if you have any problems with pages or database searches." - (Index Fungoram, 2013)

Fungal Name — http://www.fungalinfo.net/fungalname/fungalname.html

This is a third site to register fungi.

Assembling the Fungal Tree of Life - http://aftol.org/

This project is dedicated to significantly enhancing our understanding of the evolution of the Kingdom Fungi in a genealogical way.

ATTC - http://www.atcc.org/Documents/Learning_Center/Resources_for_Microbiology.aspx

The American Type Culture Collection (ATCC) is a private, not-for-profit biological resource center whose mission focuses on the acquisition, authentication, production, preservation, development and distribution of standard reference microorganisms, cell lines and other materials for research in the life sciences.

CBS-KNAW Fungal Biodiversity Center - http://www.cbs.knaw.nl/Collections/BioloMICS.aspx

Persoonia - http://www.persoonia.org/

"Persoonia is an international, peer-reviewed, open-access, full color, fast-track journal, with papers published monthly. Published papers are immediately distributed to several libraries (for effective publication under the International Code of Botanical Nomenclature). Papers are also bound into two volumes per year (June and December), which can be ordered online. The journal strongly supports good practice policies, and requires herbarium voucher specimens to be deposited in a herbarium with an online database such as the National Herbarium of the Netherlands (L), cultures and DNA in long-term genetic resource collections such as the Centraalbureau voor Schimmelcultures (CBS), sequences in GenBank, alignments in TreeBASE, and taxonomic novelties in MycoBank.

Persoonia aims to publish papers dealing with molecular systematics and evolution of fungi. A further aim is to promote fungal taxonomy by employing a polythetic approach to clarify the true phylogeny and relationships within the kingdom Fungi. The journal publishes high-quality papers elucidating known and novel fungal taxa at the DNA level, and also strives to present novel insights into evolutionary processes and relationships. Papers to be considered include research articles, topical and book reviews." - (Persoonia, 2012)

Notes Regarding The Criteria For Publishing A New Species (Writing a Scientific Article)

After a description is written it must be published. The criteria between these journals will vary, but in general they require the following:

✓ Peer review, in which the authors send their final manuscript text and illustrations to two expert peer reviewers. (Peer reviewers return complete comments to the author and the expert review comments to the Editor-in-Chief.)

✓ Nomenclature & presubmission review, in which authors send their peer-reviewed text files (no graphics) to the Nomenclature Editor, who assigns a permanent accession number to each manuscript and reviews the formatting and nomenclature.

✓ Final submission, in which authors send all text and illustration materials together with their submission form to the Editor-in-Chief. The Editor-in-Chief, who is available to answer questions at any time, will guide the authors through final submission to publication.

Additionally, the paper should be formatted, unless otherwise advised, in the following general manner:

Title
Abstract
Key Words
Article Info
Introduction
Materials And Methods
Collecting And Field Sites
Cultures And Media
Isolation Methods
Microscopy
Physiological Tests Or Chemotaxonomic Methods
DNA extraction, PCR Amplification, DNA Sequencing, And Phylogenetic Analysis
Results
Taxonomy
Discussion
Illustrations/Photos/Graphs
Acknowledgments
References

A List Of Mycological Journals

http://www.pensoft.net/journals/mycokeys
http://imafungus.org/
http://www.mycotaxon.com/instructions.html
http://www.mycologia.org/content/104/1/331.full
http://dl.begellhouse.com/journals/708a ... 17c52.html
http://www.czechmycology.org/czech-mycology-content.php

For a far more detailed international list please visit: http://en.wikipedia.org/wiki/List_of_mycology_journals

The Peer Review Process: How To Proceed And What To Expect

The purposes of the peer review process are normally: To prevent inaccurate and/or biased information going into the scientific community, to have the work reach its highest potential before publication, to meet the journal's standards, to improve the overall article in any ways possible, to provide credibility (not only to the author(s) but to the publishing organization), and to insure the work is relevant and clearly written. It is also helpful to have the article build upon previous literature.

The peer review process may include two phases or groups: Peer review by peers selected by the author followed by peer review by peers selected by the journal. Each review phase usually consists of 2-3 reviewers. This process should not be long, depending on the topic, but should take as long as the reviewers need to adequately and honestly review the work.

Articles on the Peer Review Process

http://www.peerreviewcongress.org/index.html
http://advan.physiology.org/content/27/ ... l.pdf+html
http://www.nature.com/nature/peerreview/debate/
http://www.nature.com/authors/policies/peer_review.html

It is not odd for an author to share authorship will an additional mycologist (or two) who peer review the article.

*Note: In addition to publishing a species, the new listing must also be published to an international database. The two most used are Index Fungorum and MycoBank.

Requesting And Viewing Collections Held At Herbariums

As the world wide web becomes increasingly helpful for nations to freely exchange knowledge with one another, online (and viewable) herbarium collections are becoming more prevalent, although there is still much work to be done. It is foreseeable that one day every collection in every legitimate herbarium will have been posted online with a series of pre-determined photographs and micrographs. These collections will also have undergone DNA sequencing and this information will be included with the description.

In the interim, collections are loaned to institutions for study by affiliated individuals - for identification and taxonomic purposes. The following, basic guidelines should help in understanding some of the process:

✓ Loans may consist of a single specimen, or several thousand specimens, depending on the research requirements of the researcher.

✓ The borrowing herbarium has the responsibility for the secure custody and proper return of the specimens. Specimens may not be removed from the institution to which they were loaned without prior permission and appropriate paperwork.

✓ The specimen(s) are studied using the lending herbarium's guidelines.

✓ The request must come from the director of a unit or the curator of the receiving herbarium.

✓ Loans must be stored in insect-proof herbarium cabinets at all times, except when being studied actively.

✓ All portions of the specimen must be returned, except those tissues consumed in DNA extraction or other types of morphological studies where prior permission was given to remove material.

✓ Type specimens may be available for loan only by special request.

✓ Loans must be annotated unless prior permission was given to return material without annotations.

✓ The lending institution should be acknowledged whenever its collections are used for publication or electronic transmission.

✓ Scientific papers, reports, or observations of the loan should be provided to the lending herbarium without cost.

Herbarium Collections Viewable Through Websites

A growing number of herbaria are slowly inputing the data from each individual collection they own and placing the electronic knowledge, including photographs, into a public database. This has several advantages and is in my view a very progressive step forward in data sharing. Electronic copies of field photography, microscopic photography, collection notes, and links to other sources relevant to the collection can be included and save every institution time, money, and energy. This electronic approach should be the mainstay requirement of all institutions so we are not doubling, tripling, or more - our efforts in studying biology (in a repetitive and duplicative way). All of these collections can be provided online through a URL by the organization with full, free access or uploaded into a larger database. Alternatively, herbaria wishing to insure the progress of the entire planet can commit to getting (gradually) all type collections (and relevant collections) into an international biodiversity database. EOL (which takes data from a few sites automatically after permission) is one that I support partnering with (http://eol.org/about).

Keeping A Personal Mini-Herbarium At Home

Many collections of mushrooms have been put back into nature and later this was regretted by the handler. Instead, it is both realistic and helpful to keep a personal, mini herbarium in the home. This can be done a number of ways but generally includes a *hardware and craft cabinet* or a similar container of your choosing. Each collection is thoroughly dried using a dehydrator around 105 degrees fahrenheit and then placed into sealed ziplock bags. A label with the MushroomObserver number, species name, and collection date are included inside the bag or taped to it. It is a good idea to add a small desiccant packet inside each bag as well. MushroomObserver.org now has a selection to indicate if the collector has a saved herbarium collection for each observation.

Submitting & Developing Herbarium Clonotypes

Above: Courtesy Mycologist Mike Wallace. These clonotypes can later be dried and stored in an herbarium for DNA and chemosystematic studies.

Clonotypes are herbarium collections of cultivated mushrooms propagated from (and are clones of) the same fungi from which a type specimen was made. Clonotypes can be propogated using one of the following three methods: The first is cut out a small piece of living tissue from one of the living mushrooms using a scalpel and transferring it to antibiotic agar or antibiotic liquid culture.

Below: An unidentified mushroom in the genus xyz is placed on alcohol-soaked blotter. The mushroom is cut in half or cautiously ripped in half to reduce contamination. Here the mycologist has the choice of selecting tissue from the stipe center or the pileus trama.

xyz

Once a pure, healthy mycelial mass is obtained it can then be transferred to a similar substrate that the

original specimen was found growing in. With patience and experimentation, new mushrooms can be developed indoors or outdoors.

Below: Within 24 hours of collecting this mushroom it is placed on 91% alcohol-laden paper towels in front of a flow hood, then cleaned (on the stem and pileus) with a q-tip and 91% alcohol after first removing any debris from it. The mushroom cap is broken in half. Newly poured but cool-enough petri dishes are now side-by-side with the clone origin. A traditional clone starter section is taken with a scalpel from the pileus just above the gills of a freshly harvested specimen. This section - and several additional ones - are transferred in front of a laminar flow hood and placed onto newly poured petri dishes filled with antibiotic malt extract agar.

xyz

Below: Another method, available only for a select group of wood decomposing mushrooms, would involve stem base transfer to cardboard. This requires taking gently uprooted mushrooms and immediately snipping the stem bases free. The base(s) are then placed in between two ideal-looking pieces of hydrated, corrugated cardboard. These cardboard sandwiches can then be transferred into sealable (but not air tight) tupperware containers and timidly hydrated when necessary. Once colonized, the cardboard can be used outdoors on a recommended sterile substrate and grown to maturity. The possibility for indoor growth exists but could prove difficult.

xyz

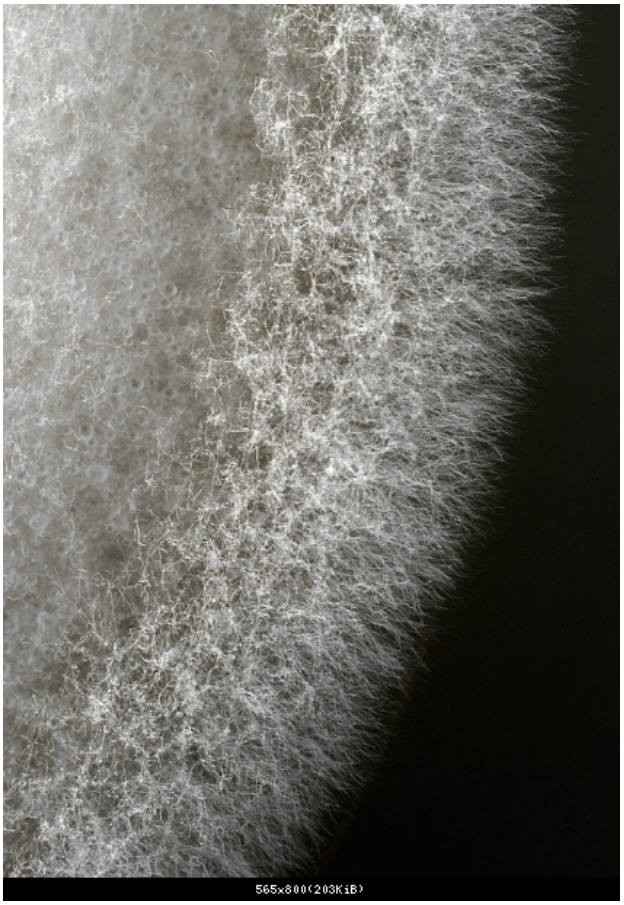
Other areas recommended for cloning including the upper portion of the stipe and the area just above the gills into the pileus trama.

If A Clonotype Is Not Possible

Below: It is possible to begin growing the mushroom from spore print and dealing with the potential challenge of gradually, patiently getting to a pure culture on antiobiotic agar. It is also possible to strike pure mycelium without trials and tribulations. To obtain spores that will not require a challenging adventure into sterile culture, a more controlled spore printing method is performed with freshly harvested mushrooms for only two hours.

If you are gathering a mushroom from the wild for agar, avoid touching the gills and pick one or two pristine specimens. Immediately place them in a clean tupperware container and head back. Upon returning from the field, wash your hands thoroughly and use an unexposed sheet of typing paper or sheet of tin foil and place it on a clean, hard, flat surface. Get an additional tupperware container without the lid and clean it with isopropyl alcohol and paper towel. Set it upside-down on-top of the typing paper or tin foil. Get two sterile, unexposed microscope slides and handle them by the edges. Place them inside the tupperware area where you'll be doing the prints. Next, swiftly remove the stems from the mushrooms and place the caps on-top of the slides for no more than a couple of hours. Remove the caps from the slides at this point and leave the tupperware container over the slides for a couple days minimum so the spores can fully dry. They are now ready for agar work in front of a flow hood (possibly a glove box) - or if the occasion arises, a sterilized liquid culture jar.

Microscopy of Myceliums: An Introduction



Above: Mycelium grown on agar and viewed at a distance (Photograph by Cortinariologist Mike Wallace)

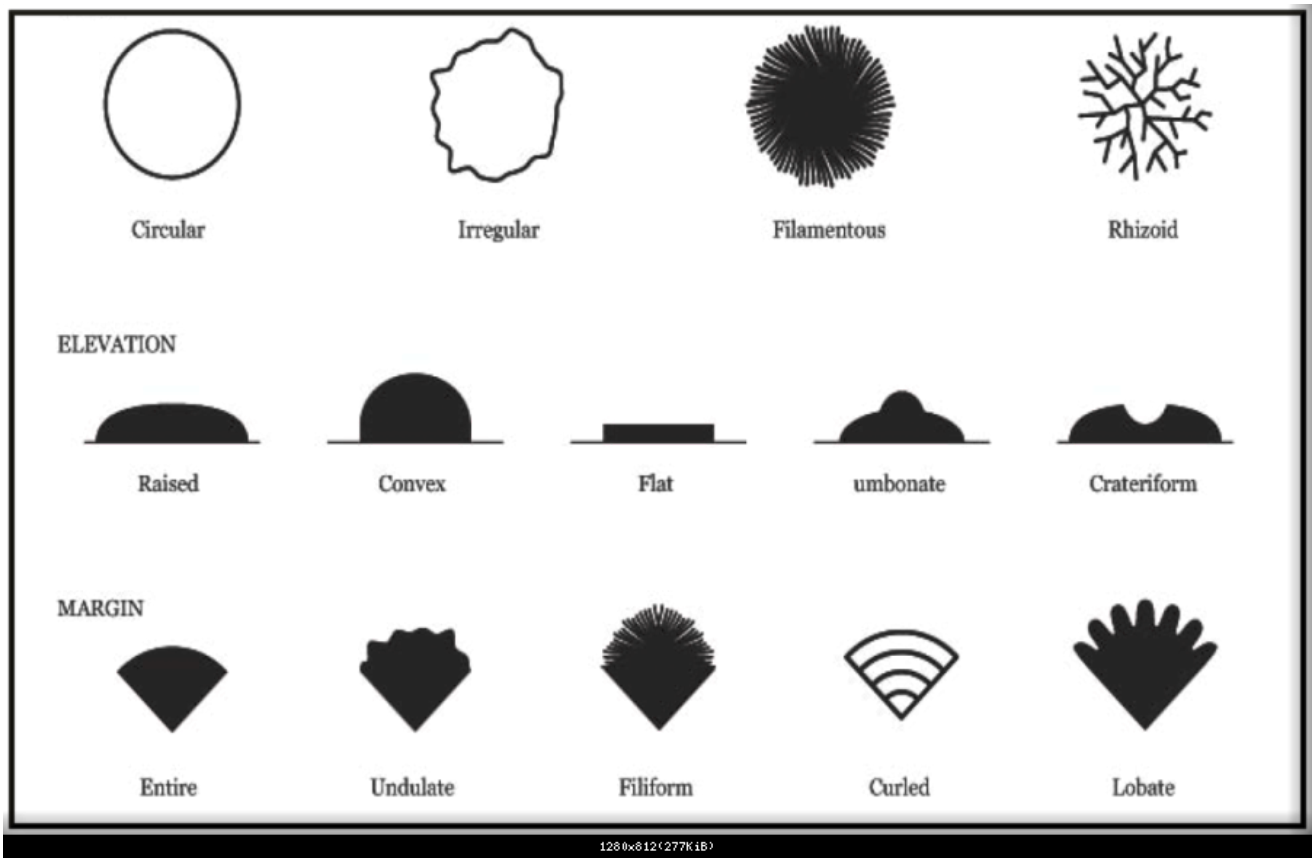
Mycelium is simply a mass of hyphae. With regard to gilled mushrooms, this mycelium (hyphae) can be composed of two to tens of thousands of different mating types. A few unique identifying microstructures can be found including: Mycelial cystidia, clamp connections, and zzz.

Mycelium Characters Used in Taxonomy (Both Microscopic And Macroscopic)

- Thin and thick-walled hyphae
- Mycelial Cystidia
- Aerial Hyphae
- Vegetative Hyphae
- Advancing Zone
- Conidia
- The presence or absence of chlamydospores
- The presence or absence of arthrospores
- Clamp connections
- The presence or absence of anastomoses
- Form - Circular, filamentous, etc. (See form types below)
- Size – The diameter of the colony (colonies). Tiny colonies are referred to as *punctiform*.
- Elevation - This describes the side view of a colony. Turn the Petri dish on end.
- Margin/border – The edge of a colony. What is the shape of the edge of the colony when viewed macroscopically & microscopically?

Ł Surface - e.g. smooth, glistening, rough, wrinkled, or dull.
Ł Opacity - For example, transparent (clear), opaque, translucent (like looking through frosted glass), etc.
Ł Mycelium color (Pigmentation)
Ł Observable transformations/phases during colonization on agar (i.e. some hypha starting perfectly vertical and touching top of dish cover, then collapsing into horizontal hypha upon maturation, color beginning white and transforming to light green and finally dark green upon maturation, etc)
Ł Reaction to sectioning (damage) including color changes and regenerative hyphal formation(s)

Macroscopic Forms of Mycelium Grown on Agar



Above: Common macroscopic shape formations of mycelium found in the Kingdom Fungi

Studying Intentionally Dried Mycelium

Microscopy with a light microscope will not provide many details, which means the reliance on more expensive microscopes. One method used to study mycelium (hyphae) is taken from a 2011 article titled, *Taxonomical Significance Of Microstructures In Pure Cultures Of Macromycetes*:

A scanning electron microscope (SEM) is used between 100x - 18,000x. Mycelium cultures are grown on agar in petri dishes, but five to seven sterilized 4x4mm cover glass slips are placed ontop of the agar after initially streaking with spores or transferring a mycelium wedge. The mycelium grows on top of the cover slips, which can then be removed and placed on microscope slides. These slides are placed into a sealed glass container to fix the mycelium with osmium tetroxide vapour (1% solution) for 96 hours. Afterwards, the slides are placed into empty petri dishes to dry for 72 hours. They are then covered with

gold with a vacuum spray gun JII-4x with rotation and made ready for microscopic observation with the SEM.

Living Mycelium Techniques

Below: Courtesy Mike Wallace

The simplest method for viewing mycelium cells is to take a piece of (very) clear tape and gently touch a petri dish of mycelium with the sticky side. Place the tape on your microscope slide as if you were labeling the slide, without crushing the mycelium cells (hyphae). This holds the mycelium in a flat plane so it stays in focus. Obviously this is inferior to mounting a proper slide but it can be done in seconds.

To see clamp connections, slowly raise and lower the stage to change the focus point as you look at intersections until you find one. Clamp connections will have a thy bone-like shape somewhat similar to a human hip joint. Different magnifications may help the clamp(s) to stand out visually, as well as an appropriate stain.

xyz

Below: Hyphae fusion

xyz

Below: Hyphae branching

xyz

Below: Forms of Hyphae

xyz

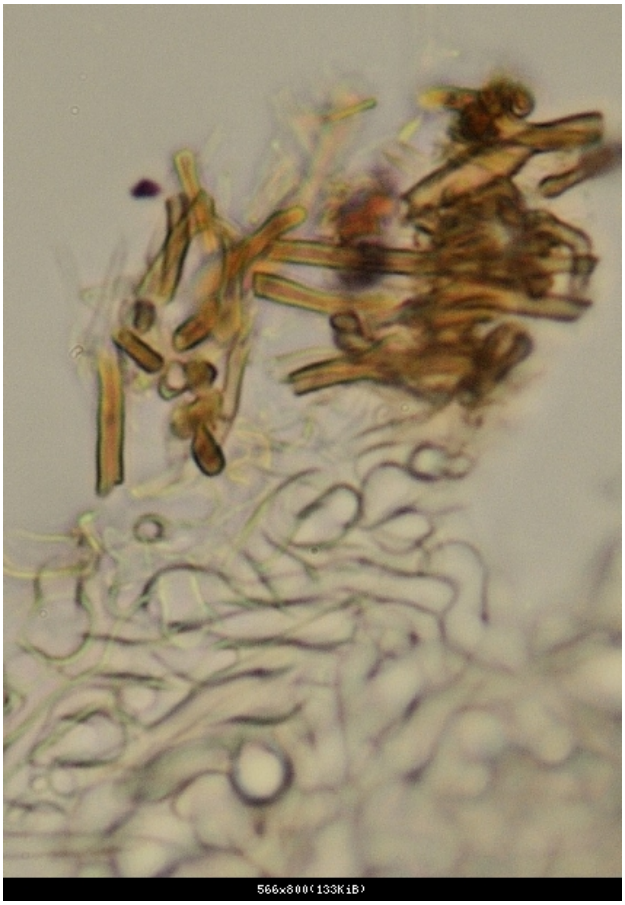
Types of Hyphae Clamps (Short and long, high and low, small and large, gently or abruptly curved, medallion-type and without a slit, single, coupled and in whorls, as well as clamps occurring on anastomoses). zzz

xyz

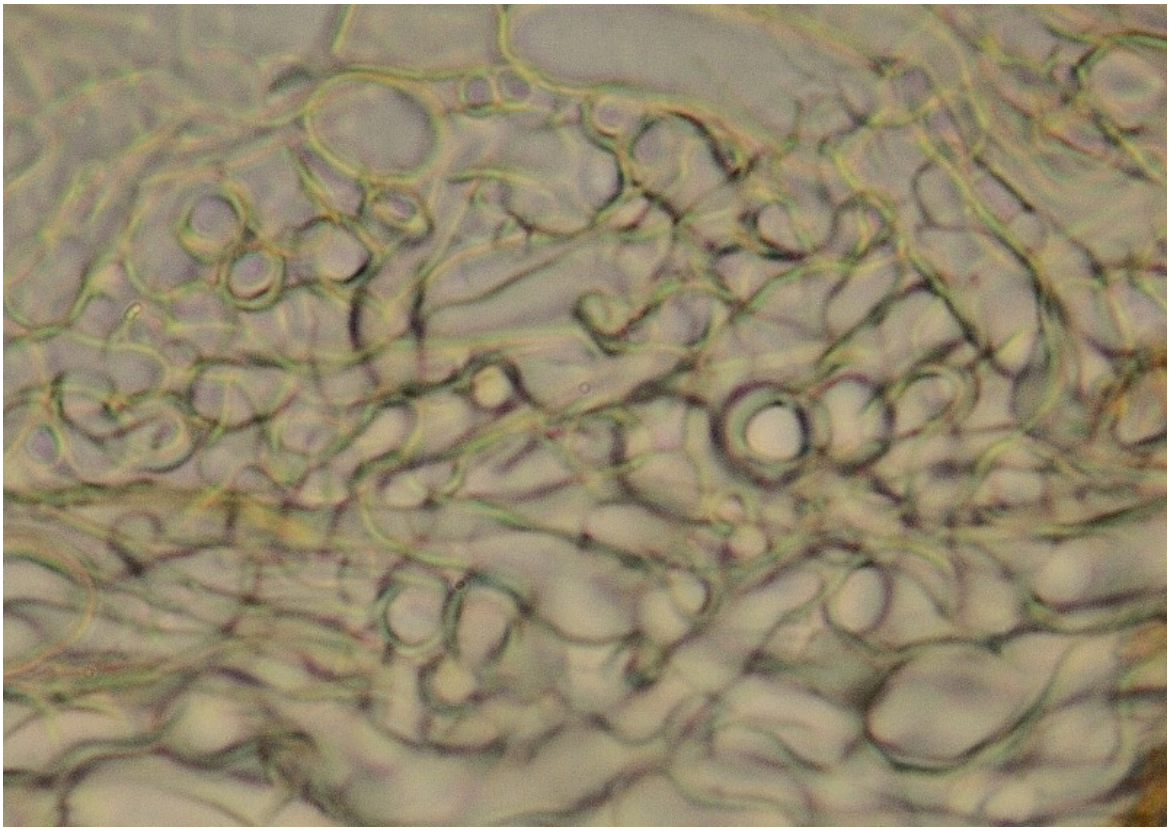
Microscopy of Sclerotia

Below: A macroscopic view of a sclerotium from the mushroom *Psilocybe galindoi* [Microphotograph by Mike Wallace]

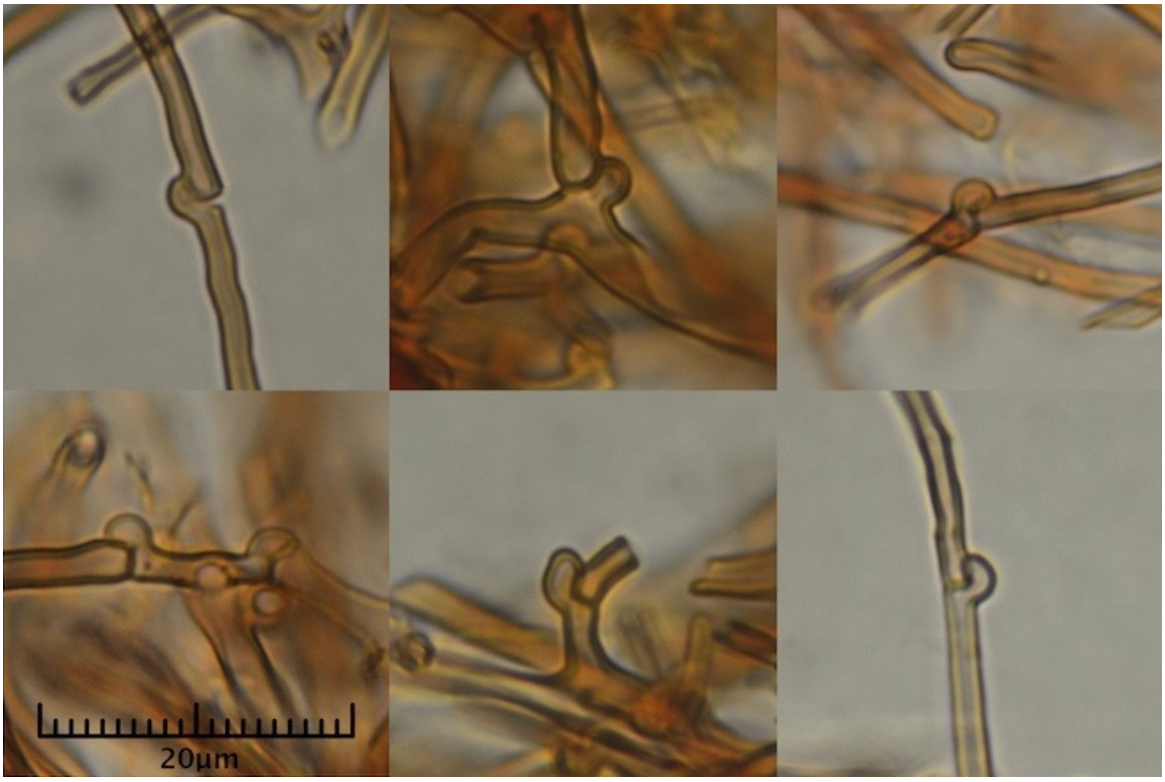
Below: The interesting pigmented cylindrical hyphae that make up the surface of the sclerotium of *Psilocybe galindoi* courtesy of Mike Wallace. At the bottom are the non-pigmented, inflated cells that make up the inner flesh of the sclerotium. These inflated cells resemble the cells just below the pileipellis of the fruit bodies.



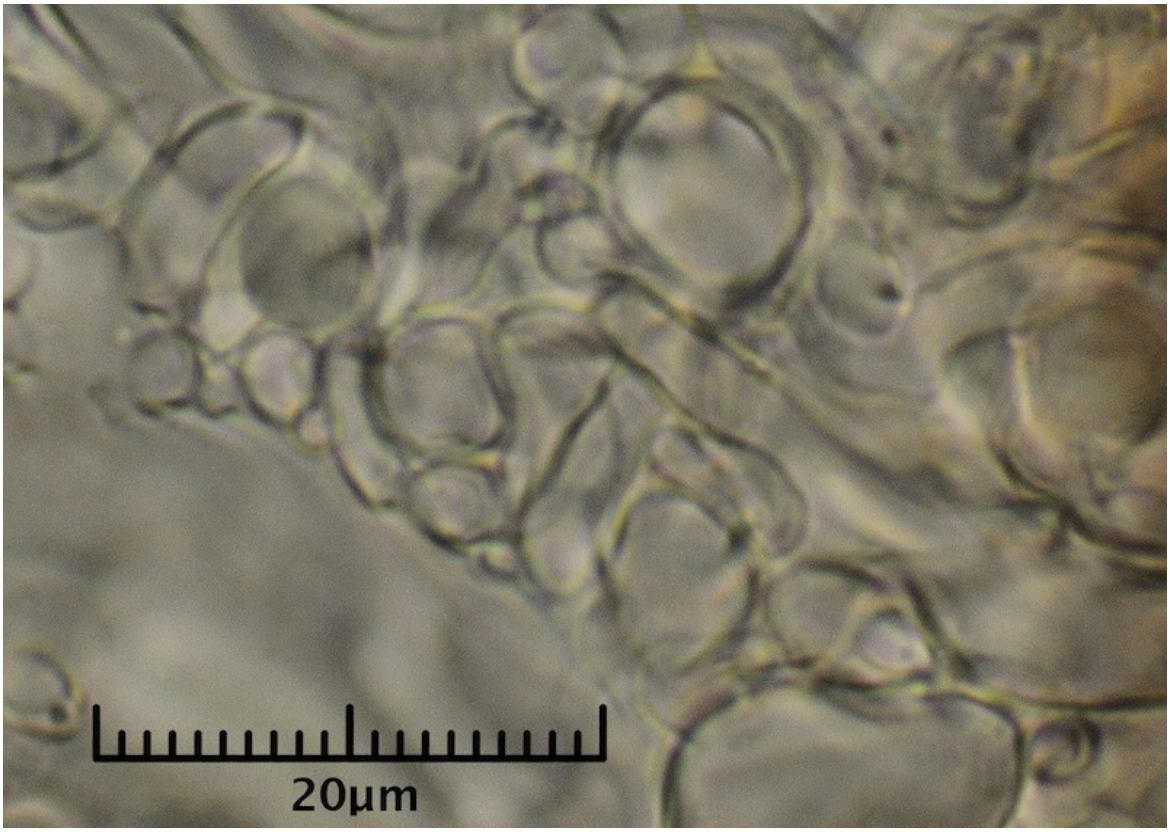
Below: Slerotia cells of *Psilocybe galindoi* viewed. These are the inflated cells of the inner flesh. [Courtesy Mike Wallace]



Below: 1000x magnification. A composite of six images showing the clamp connections present in the pigmented cells at the surface of the sclerotium. Species is again *Psilocybe galindoi*. [Courtesy Mike Wallace]



Below: Also at 1000x. The cells that make up the sclerotia's interior flesh. Species = *Psilocybe galindoi*. [Courtesy Mike Wallace]



Sclerotia can survive many years and can show different microscopic features based on age.

Sclerotia Microstructures with Taxonomic Value

Crystalline Initials

The Rind Layer
The Medulla Layer
Cortex

Preparing a Sclerotia Cross Section

zzz and xyz

Preparing a Sclerotia Scalp Section

zzz and xyz

Microscopy of Mycelium & Plant Root Connections: An Introduction

Below: The mycorrhizal mushroom *Tricholoma matsutake* courtesy Wikimedia Commons

There are four basic types of myceliums for gilled fungi worthy of further microscopic research - three of which are connected to very cool plants (including trees which are simply large plants). These three mycelium types are mutualistic mycelium, parasitic mycelium, and mycorrhizal mycelium (which is usually mutualistic but can be slightly pathogenic to the plant/tree).

Below: A connection of a ZZZ mycelial thread to a root of the plant ZZZ

xyz

Mushroom Identification And Chemical Analysis: Detecting & Measuring

Fungi have a quite a history with Humanity. Besides being genetically more similar to human beings than plants, fungi have - for millennia - provided Humanity with food and medicine. Fungi have given us penicillin derived from *Penicillium* species, statins from oyster mushrooms (*Pleurotus*), an anti-tumor polysaccharide from the shiitake (*Lentinula edodes*) mushroom, a cancer treatment medicine called Polysaccharide-K from *Trametes versicolor*(used for immunity), and other notable medications.

Chemical analysis is important for identification of mushrooms and in many ways has been overlooked throughout human history. Only recently did Humanity discover the above mentioned medicines. New ones are in trial and others are being researched. What has not been provided to the mushroom hunter or amateur mycologist is a group of contacts who have the ability to test for any type of chemical that Nature has created in the 1.5 million estimated fungi growing from the Earth. Such individuals should not be without resource in the year we now find ourselves living in.

I will leave this dilemma to you, the reader, to sort out.

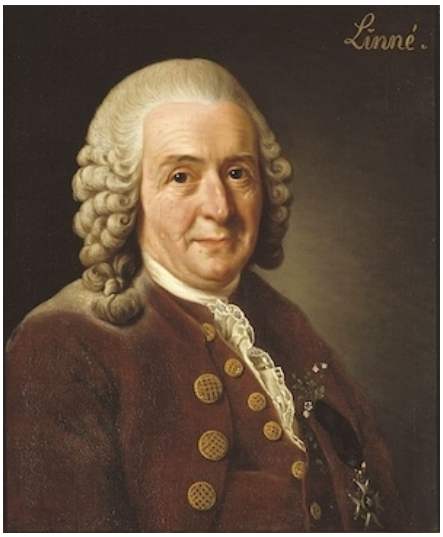
For those of you interested in pursuing chemical identification of your gilled mushrooms I can only discuss equipment: A mass spectrometer/gas chromotograph. It should be noted that genera exist which are separated from one another based on chemical identification.

Mushroom Pigmentation (Why Color Occurs and How to Test for the Presence of a Pigment)

zzz

A pigment is a material that changes the color of reflected or transmitted light as the result of wavelength-selective absorption.

Linnaean Taxonomy Naming System



Above: Carl Linnaeus courtesy Wikimedia Commons

A brief mention should also be made regarding Linnaean naming. While many mushrooms have common (nick) names, all mushrooms are given scientific names. The naming system originated with Carolus Linnaeus who started using a two-name system: The Genus name first (capitalized) and species name

second (in lower case). (This two-part naming system is known as binomial nomenclature). This system applies far beyond mushrooms and is used for plants, insects, animals, and humans (among other lifeforms).

A genus is made up of a closely related group of species. Species are distinguished from each other based on different macroscopic and microscopic characteristics, DNA sequencing, chemosystematics, and sometimes mating studies.

A fungi's genus and species name is also known as its scientific name. Though it was once a requirement, genus and species names no longer need to be in Latin (English is sufficient). The name of a genus "may be taken from any source whatever, and may even be composed in an absolutely arbitrary manner, ..." (ICN Art. 20.1), and similarly in ICN Art. 23.1 "The epithet in the name of a species may be taken from any source whatever, and may even be composed arbitrarily ..." The ICN is available here: http://www.iapt-taxon.org/nomen/main.php

Final Notes on Publication

In 2012/2013 the ICN (International Code of Nomenclature for algae, fungi, and plants) was published under the *Melbourne Code*, updating in part the way fungi are named and described. There is no longer a requirement for a Latin description; it can now occur in English. There is no longer a need to publish the description in a hard copy, physical journal; it can now be published online. One fungi gets one name; a mycelium can not get a name and the fruiting body another name (they are one). Newly described species must be registered with a recognized repository such as Index Fungorum or MycoBank.

Fungal collectors should be noted with each listed collection.

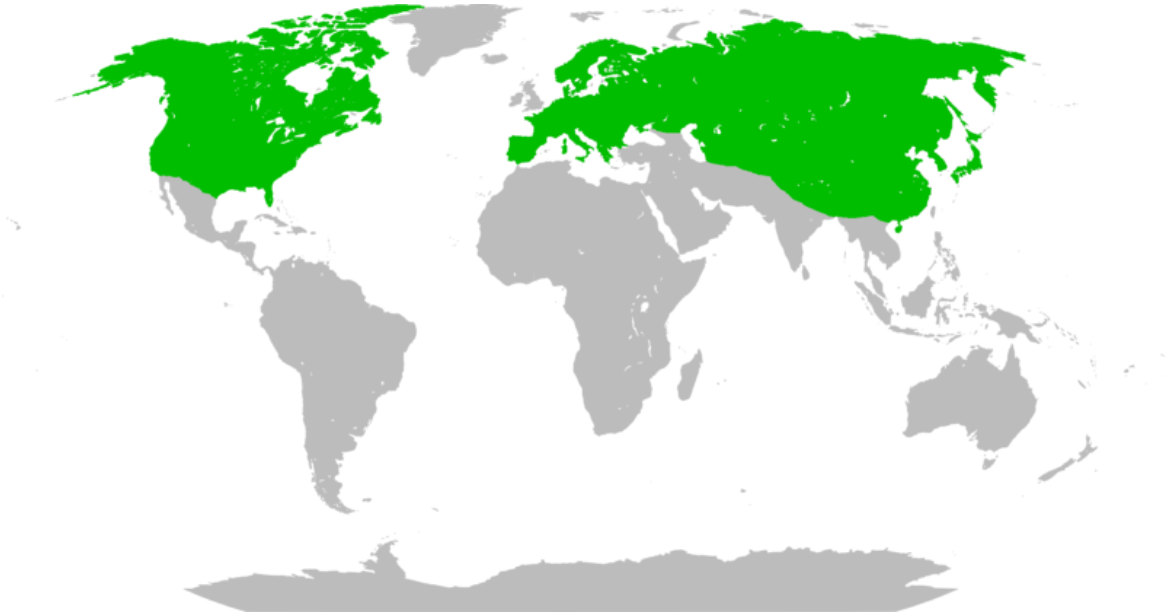
An Occurrence Map (Distribution Map): It's Value, How to Build One, & What it Tells Us Now & in the Future

As we see our planet undergo its largest ever world population by humanity, and as we see the loss of many habitats (and thus species), we will inevitably witness changes in the distribution quantities and distribution areas of many gilled mushrooms. With the legitimate although untrusted possibility of climate change also in our midst, the frequency of species occurring is also possible to transform. A legitimate map illustrating where a species has been found within a given time period can be compared to new maps over the course of decades. This alone is of some value for determining how nature is adjusting to human interaction, if not an alternative method to inform our communities of species loss and the impact it is already having on Earth.

Method One: To create a very basic map, login to a Google account and click Maps, then My Places, then Create Map. You can adjust the zoom to get closer or further. At the top area there's a blue marker to place onto the map to note an area. Mapping can be city specific using this method. The tool to the right of the blue marker will allow an entire state or area be selected by clicking different points to create a shape.

Method Two: ZZZ

ZZZ



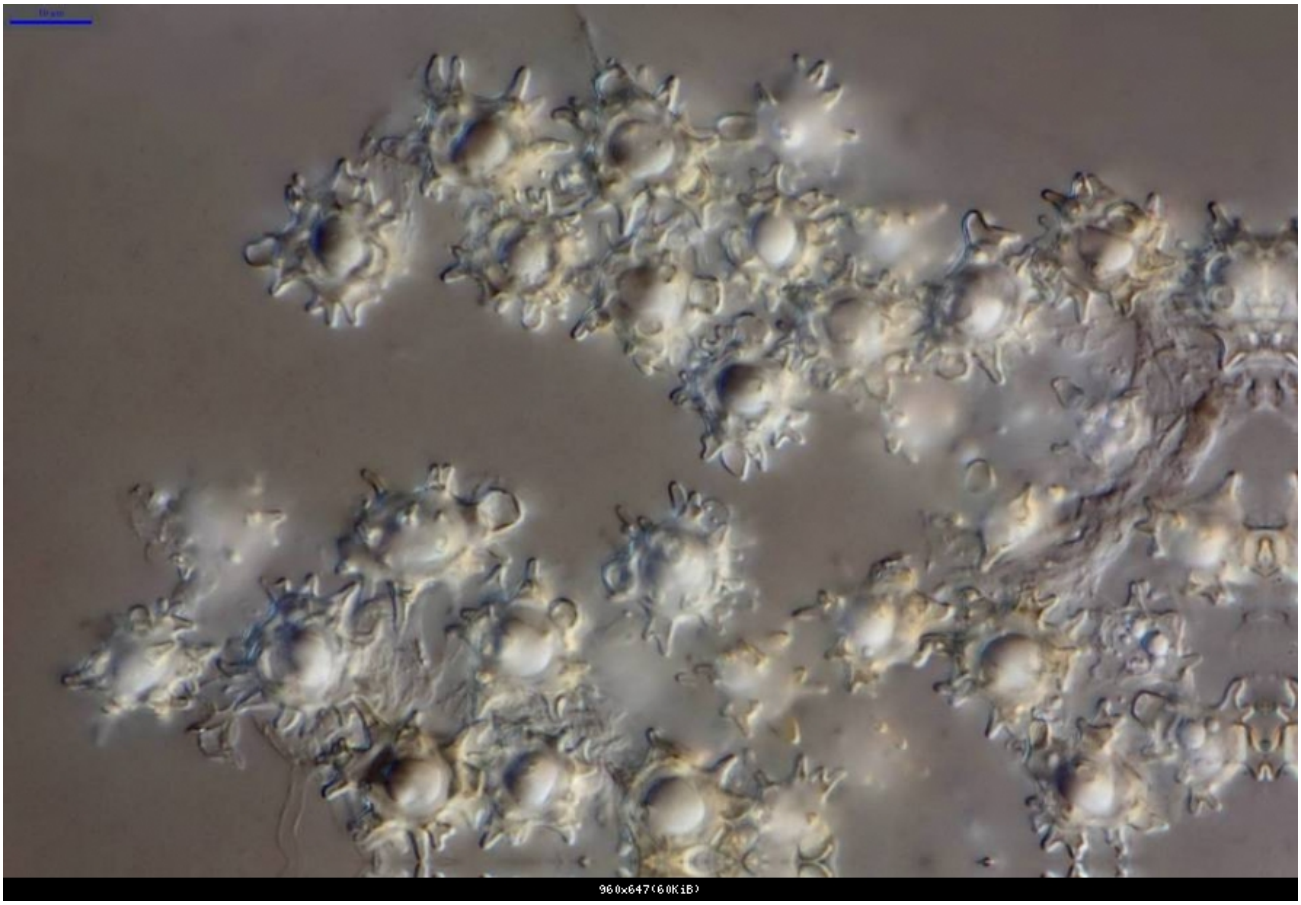
Above: A 2013 distribution map of *Tricholoma pardinum* courtesy Wikimedia Commons

Another important piece of information in describing a species is to inform the scientific community (and people in general) where the species has been collected worldwide.

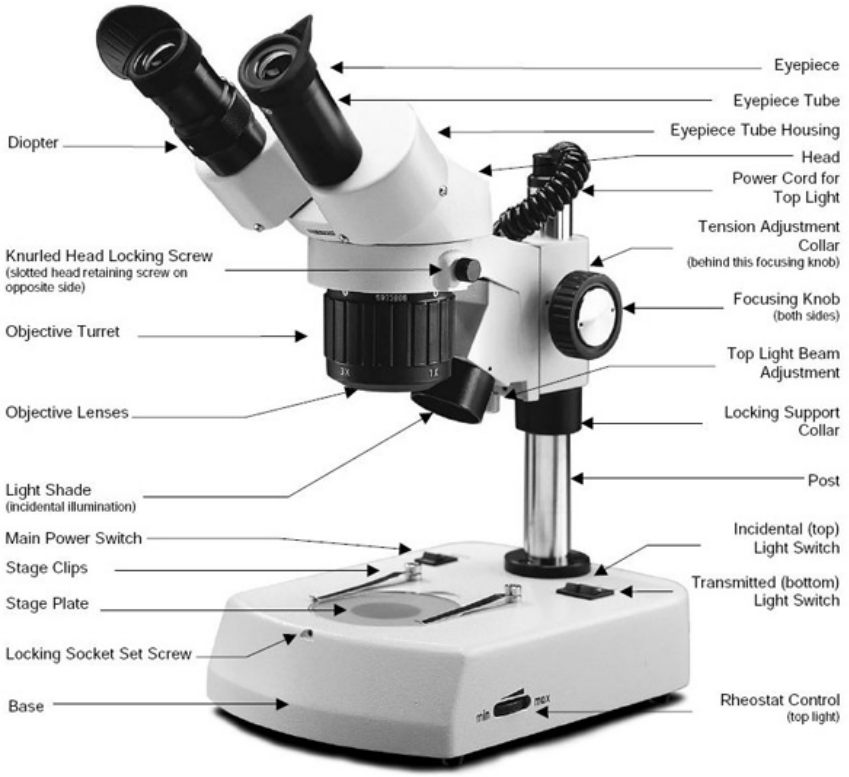
Introduction to Other Microscopes

Stereoscope, Phase Contrast, SEM, ESEM, STEM, Confocal, DIC, and More!

Below: *Asterophora lycoperdoides* spores 1000x with DIC illumination and image stacking (Microphotograph courtesy Alan Rockefeller)



Stereoscope Uses



Above: A stereoscope can sometimes be employed to view and work with smaller specimens to make either gill cross sections, preparate cut-outs, or for pellis sections

In addition to making tissue sections from size-limited specimens, stereoscopes are sometimes neccessary

for describing macroscopic features with a little bit of magnification to observer details more precisely.

Phase Contrast Microscope

A phase contrast microscope is a good visual step up from typical light microscopes, and they are very similar in many ways so it's a smooth transition (again, with the right introduction).

Below: The basic parts of a phase contrast scope

xyz

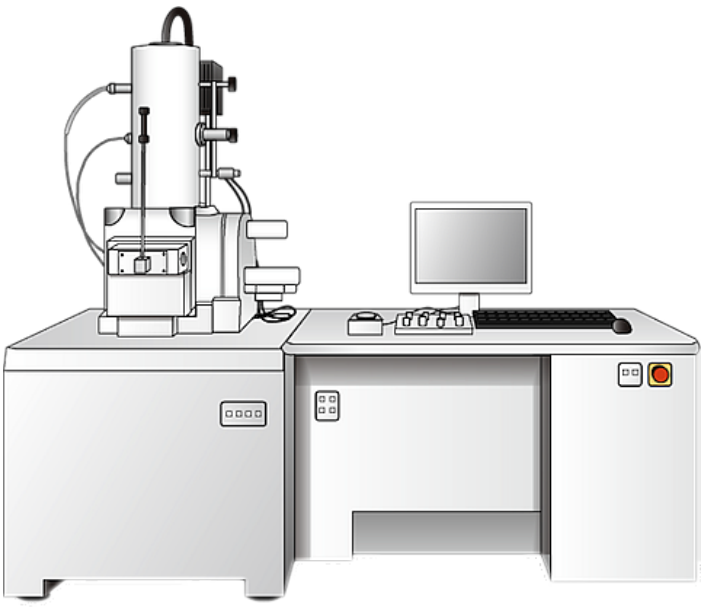
Uses for the Phase Contrast Microscope: ZZZ

Introduction to Phase Contrast Microscopy

ZZZ

Methods for a Scanning Electron Microscope (SEM)

Below: The fundamental parts of a Scanning Electron Microscope (SEM)



Uses for the SEM: To observe spore ornamention and morphology in greater detail, and to describe clamp connections in greater detail.

Below: A JEOL SEM courtesy Wikimedia Commons

Instead of using microscope slides, SEM users generally use "stubs" which are metal (and round) and have a smaller width.

Below: Stubs sitting inside a storage container when not in use. The storage container is called a "pin holder" by some companies.

xyz

Specimens are prepared in different ways, but when viewing them in "high vacuum" mode, the material must first be coated with metal inside a sputter coater.

Below: A room setup next to the SEM room has a sputter coater system that sprays gold onto the specimen before placing it in the SEM.

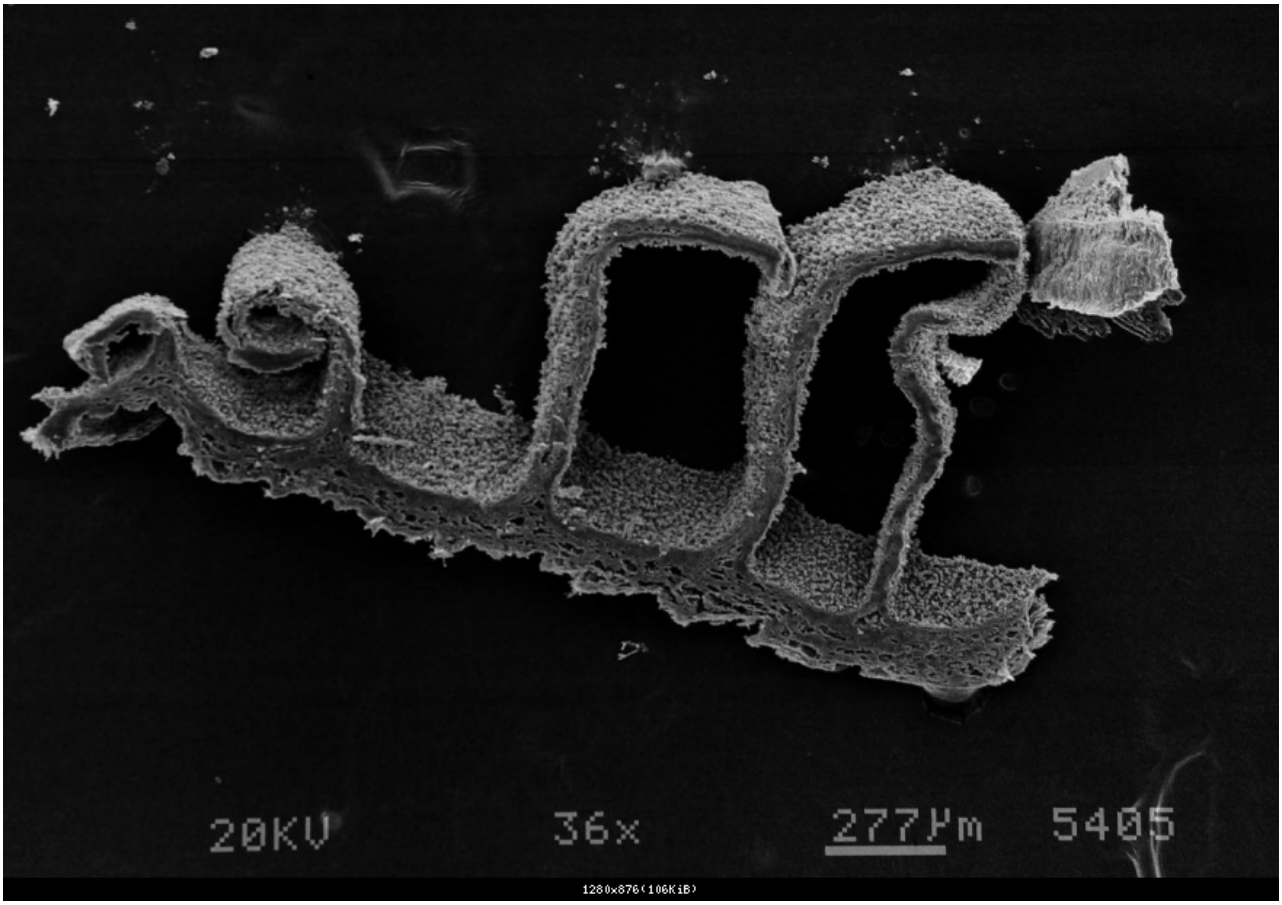
xyz

This particular SEM model has a "stage" somewhat similar in concept to a typical light microscope. There is a sizable enclosed area (with a door) where the stub sits on the stage. Considerable care and awareness of your hands is important when inside this area.

Below: The door is opened and the stub is placed onto the stage

xyz

There are multiple ways for preparing specimens, including gilled mushroom material, for the SEM. This takes place before using the sputter coater.



Above: A gill cross section (Psilocybe aztecorum) via scanning electron microscopy (Mushroom Observer No. 142666). Courtesy Alan Rockefeller.

Method One: Preparing and Viewing Spores from Spore Print

1. Have spore prints ready on desired material (tin foil, glass, etc)
2. Place carbon tape onto studs
3. Gently, methodically scrape spores from tin foil (or preferred material) onto carbon tape-covered studs
4. Sputter coat
5. Mount studs onto stage and view with S.E.M.

Note that the vacuum inside a S.E.M. is capable of "deflating" (collapsing) many spores.

Method Two: Viewing Spores from a Tissue Section

1. Attach a small piece of double adhesive tape (e.g. carbon tape) roughly 5x5mm to a stub.
2. Place fully dried mushroom material (section) ontop of the tape. This can be a small preparate cut-out or a single gill depending on the size of the stub and the size of the gill be used.
3. Sputter coat in gold (or gold and peladium)
4. Mount studs onto stage and view with S.E.M.

Method Three: Preparing and Viewing a Prepare Cut-Out

1. Make sections from fully dried mushrooms
2. Place carbon tape onto studs

3. Place fungi sections onto carbon tape-covered studs
4. Sputter coat
5. Mount studs onto stage and view with S.E.M.

Method Four: S.E.M. Method With Freshly Harvested & Sectioned Lamellae or Spores

1. Prepare several thin sections of freshly harvested material (whether it is a preparate cut-out, a section from the pileus, etc). This step can be performed "in the field" if necessary.
2. The material is now fixed with paraformaldehyde-gluteraldehyde (2.5%: 2.0%, with a pH of 7.2) for 48 hours.
3. Wash each sample three times with phosphate buffer (K_2HPO_4 with a pH of 7.2).
4. Dehydration is then done for 45 minutes per solution (in ethanol) using the following concentrations: 10% Ethanol (90% Water), 25% Ethanol, 35% Ethanol, 45% Ethanol, 55% Ethanol, 65% Ethanol, 75% Ethanol, 85% Ethanol, 95% Ethanol, followed by three more exposures to 100% Ethanol.
5. Critical point dry
6. Mount on 15mm stubs with carbon double-sided tape
7. Sputter coat with gold-palladium
8. Observe in SEM at 15kv

*This method also produces semi-permanent slides that will last approximately four years or longer.

Method Five: Preparing and Viewing a Preparate Cut-Out

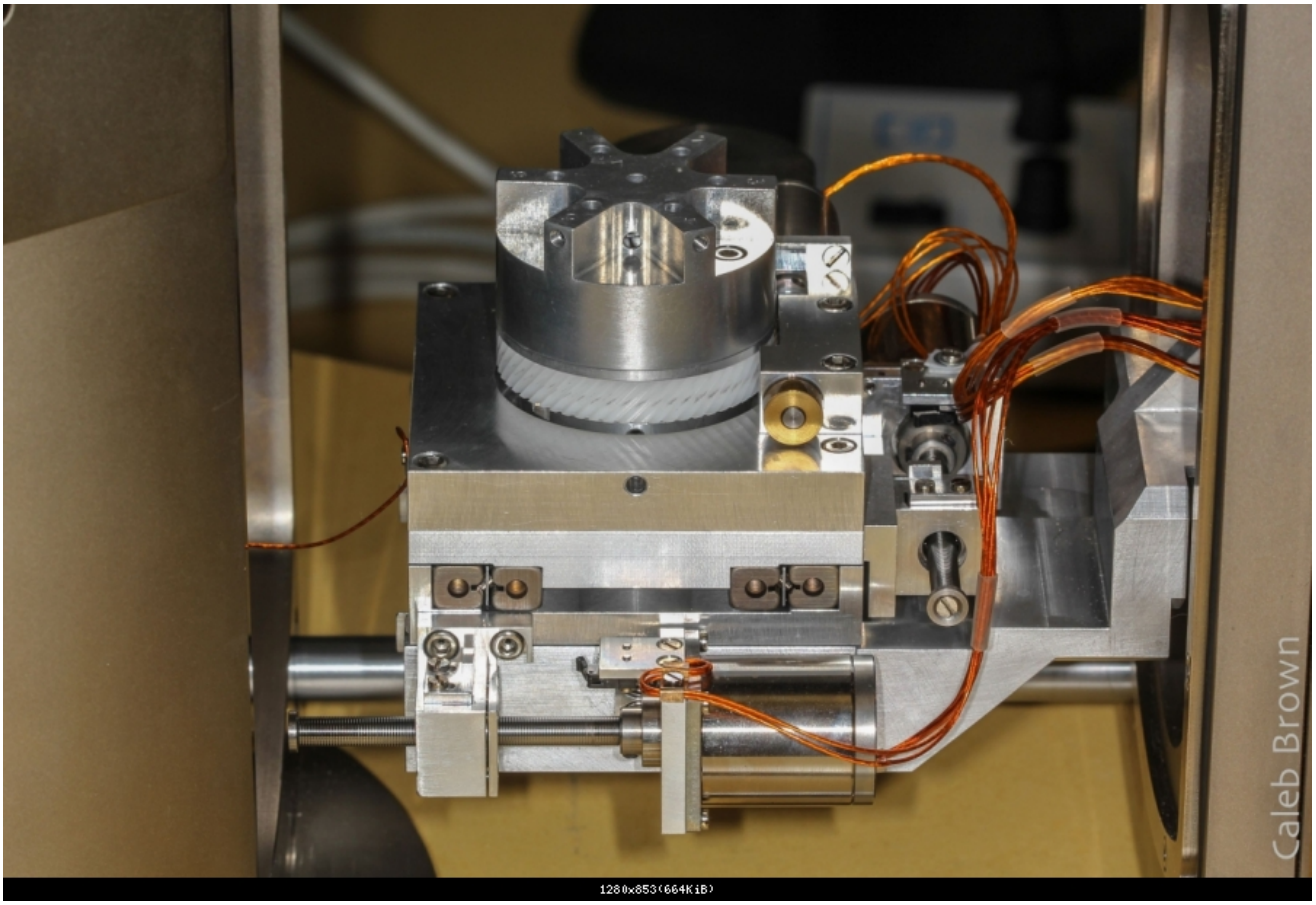
1. Beginning with newly harvested mushrooms, prepare a few preparate cut-outs and allow them to fully dry. Individually store them in screw-top vials and label them.
2. Rehydrate the material (still stored within their respective vials) with a series of acetone baths using the following method: Place all vials in a vial holder. With specimen material at the bottom of the vial, pour 100% acetone in each vial til 1/3rd full. After 10 minutes, empty the acetone and replace it with 95% acetone / 5% distilled water for 10 minutes. Replace fluid with an 80% acetone solution and wait 10 minutes. Replace fluid and use a 70% acetone solution for another 10 minutes. Replace with a 50% solution for 10 more minutes. Replace fluid with distilled water, again 1/3rd full.
3. The material must be "fixed" with primary fixative next. This requires safety gloves and a fume hood partially open. Fixation occurs at 4 degrees celcius at a pH of 7.0 in 2.5% (0.1M) phosphate buffered gluteradehyde solution. The vials are filled 1/3rd full and then refrigerated for three hours. The fixative solution consists of 50ml Sorensen's Phosphate Buffer, 10ml 25% glutaraldehyde, and 40ml distilled water.
4. Wash the material using distilled water for 10 minutes. Replace water with new distilled water for 10 more minutes. Replace a third time for 10 more minutes.
5. Fix the material a second time. Use 1% aqueous Osmium Tetroxide at room temperature for 30 minutes. Instead of filling each vile 1/3rd full, only use a few drops in each vial. Safety gloves are necessary.
6. Wash the material again using distilled water - three times as mentioned in step four (above).
7. Dehydrate the material using the following baths at 10 minutes each: Distilled water, then 50% acetone, 70% acetone, 80% acetone, 90% acetone, 95% acetone, and then 100% acetone.
8. Critical point dry to 31.1 degrees celcius at 1070 PSI using CO_2 as the transition fluid to slowly cool the chamber (cooling is done by opening the vent valve fully and the inlet valve sufficiently to maintain a chamber pressure of 300 PSI). The chamber is cool enough when liquid begins to form in the chamber and

the external surfaces feel cold. The cooled chamber is vented to atmospheric pressure and filled with 100% acetone. Mushroom material is placed in perforated snap-lid BEEM capsules and four of these per run are used in the chamber. The chamber is sealed and brought up to tank pressure, then slowly flushed with aqueous CO2 for 2-3 minutes without allowing the pressure to drop. The vent valve is closed. The power is turned on. Vent valve pressure should not exceed 1300 PSI. Once the termperature reaches 43 degrees celcius (the cut off temperature), the power is turned off and the chamber is slowly vented (120-180 PSI drop per minute). Once atmospheric pressure is reached, the dried mushroom material is stored in clean screw-top vials in a desiccator until ready for microscopy.
9. Place mushroom material on a 10mm stub. Mount using EM grade silver paint as both the adhesive and grounding device.
10. Sputter coat with gold/palladium alloy with a sputter coater. (Pressure: 40-80 millitorr. Current: 10 milliamperes. Voltage: Position 11 on this system. Timer: Auto Pulse Mode: On.) An initial 2-minute coating is applied. An additional 2 minutes is applied if excessive charging is encountered.
11. Place in SEM for microscopy at try viewing from a working distance of 10mm, objective aperture 100nm, accelerating voltage 15KV, specimen tilt 45 degrees. Some stubs may be better viewed at 25KV.

Scanning Electron Microscopes (SEMs) use electrons - instead of light - to "see" a specimen. They are much larger, expensive, and usually require in-person training sessions. Most of the same fundamental principles that you learned from the light microscope will - in relative terms - apply to the concept of the S.E.M.

You will want to print out or request a step-by-step instruction list for the exact model of SEM you are working on, which hopefully will be provided by the college you are attending/visiting. Here is a general overview of the process when you're ready to view spores:

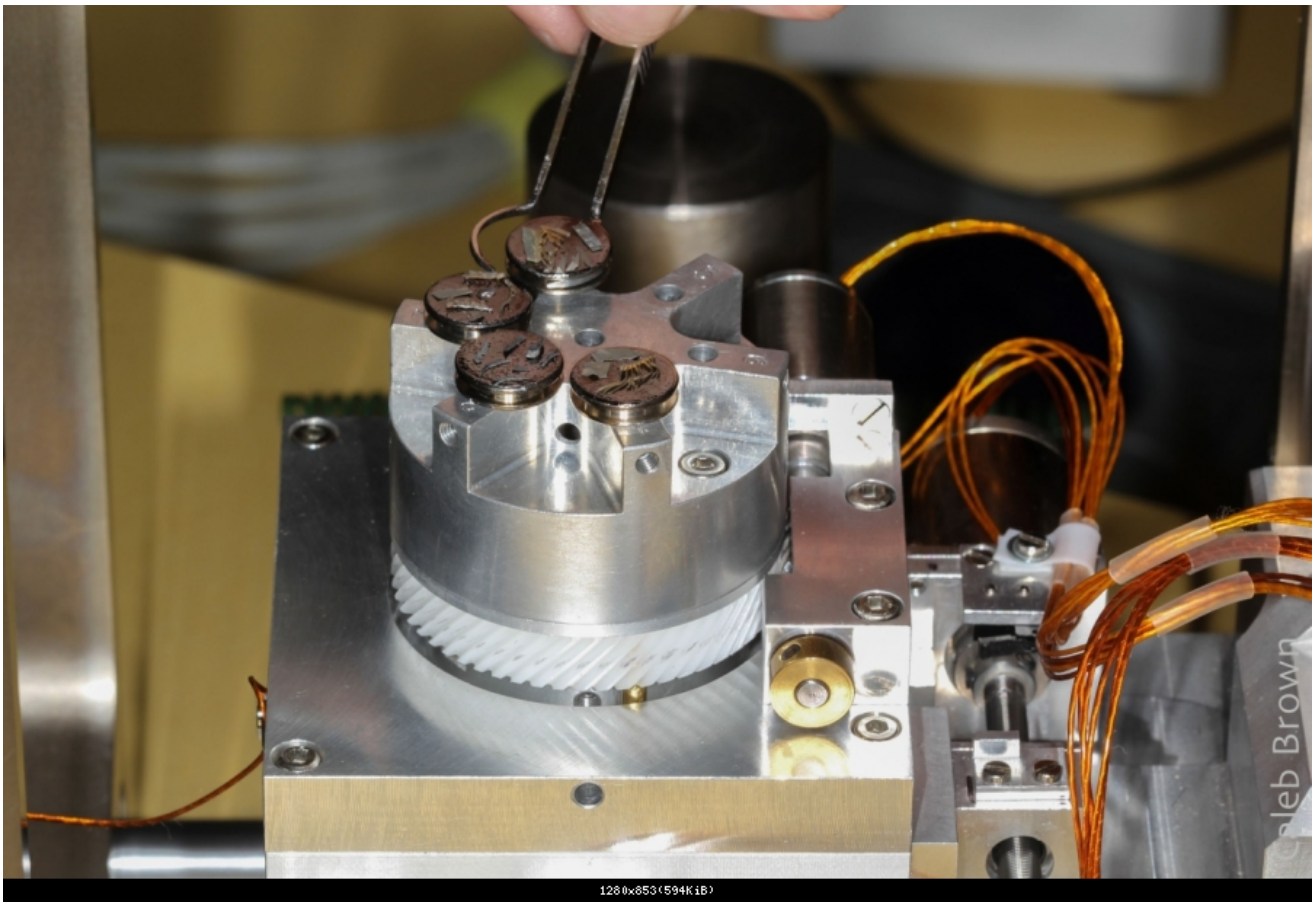
Below: A S.E.M. stage (currently empty) where the studs will be inserted for viewing (Image courtesy Mycologist Caleb Brown)



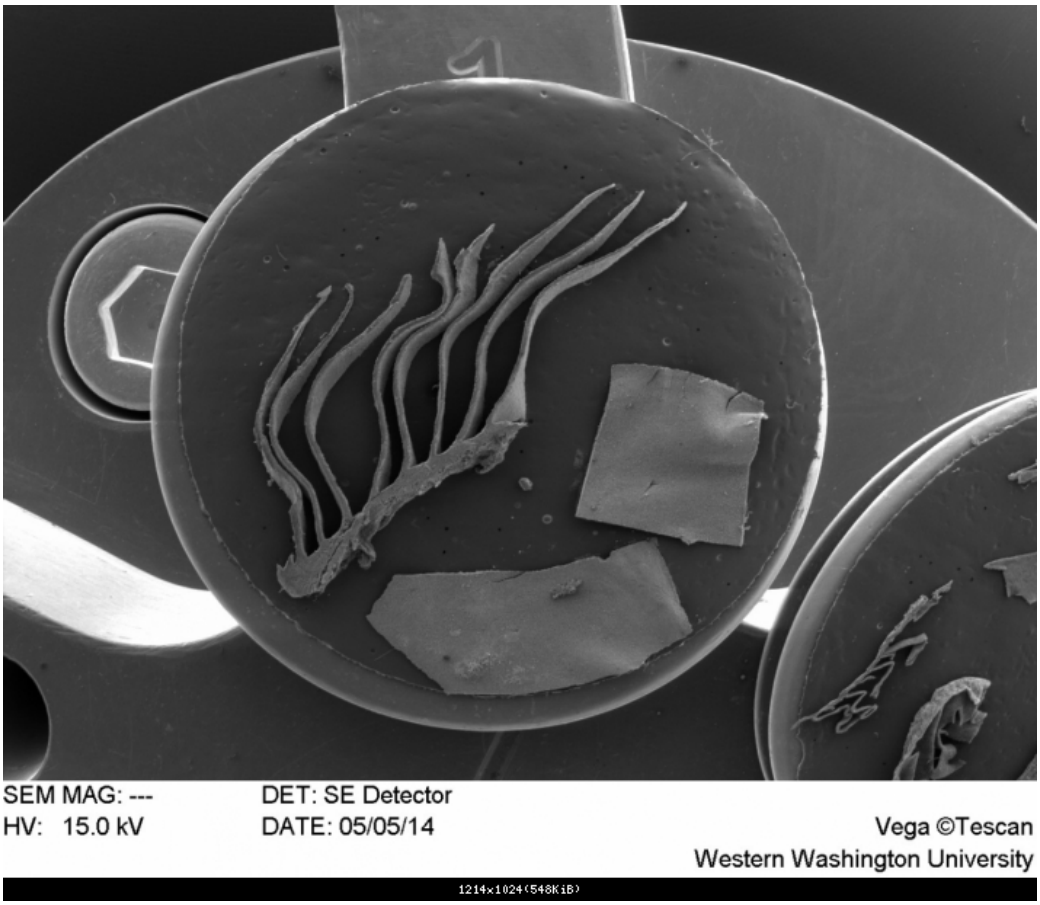
Below: Multiple studs (similar to microscope slides) are prepared before sputter coating. In the method used here, courtesy Caleb Brown, the stubs are first covered with carbon tape to better reflect electrons. This tape is double-sided and adheres to the stud while also adhering the mushroom material(s).

Below: A close-up of one of the studs after sputter coating with gold and peladium (courtesy Caleb Brown)

Below: Prepared studs are inserted onto the S.E.M. stage (Image courtesy Caleb Brown)



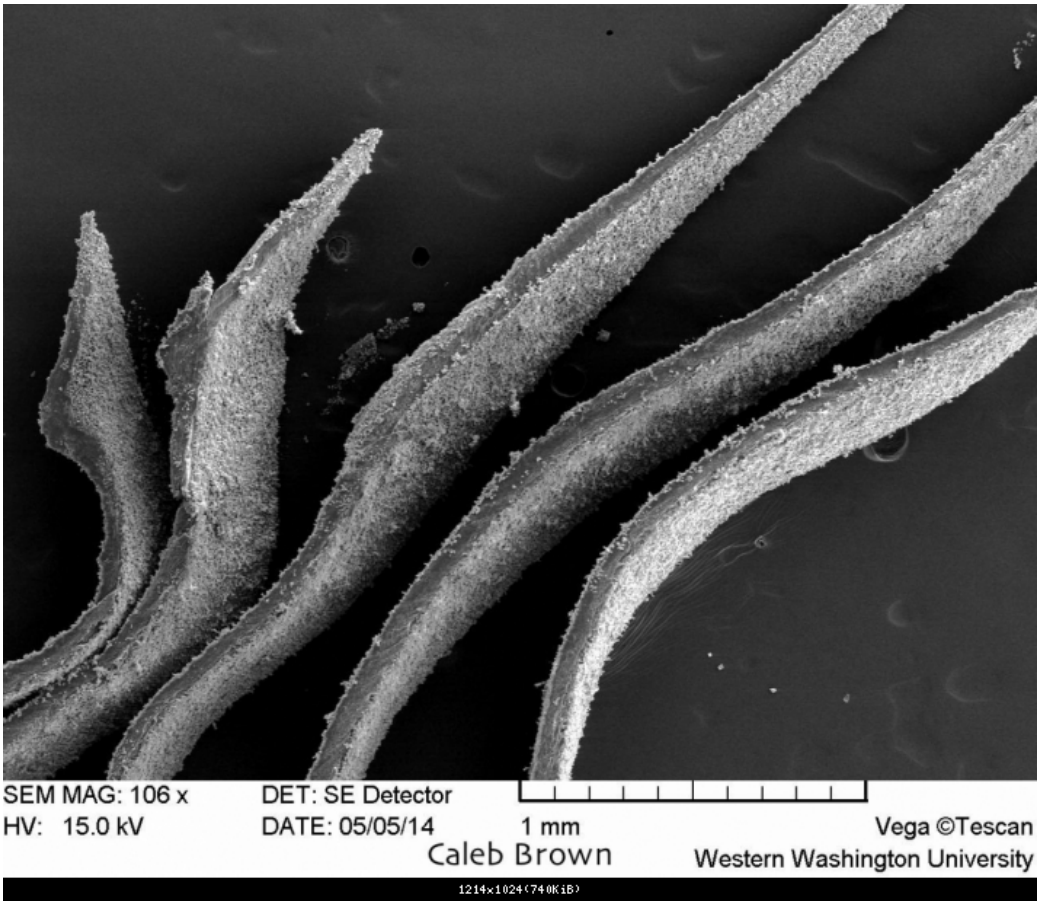
Below: A view using the S.E.M. of some of the same sections (Image courtesy Caleb Brown)



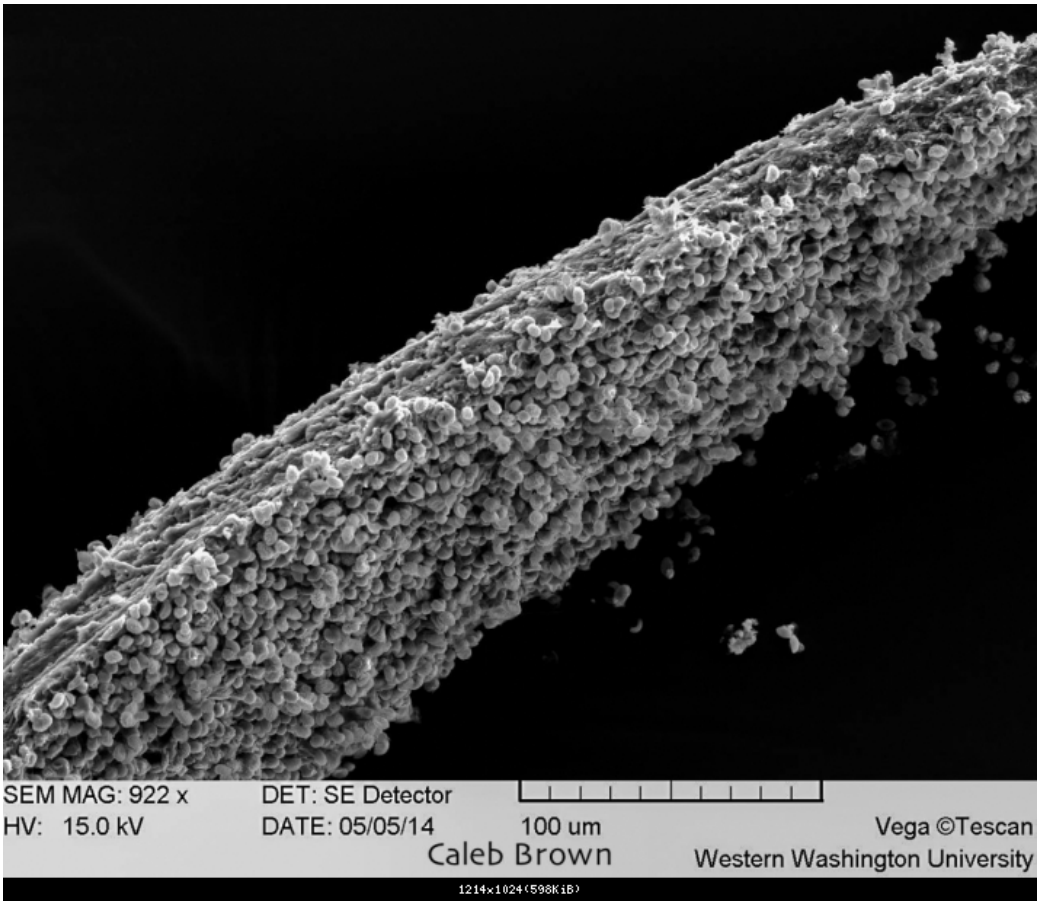
Critical Point Drying

Some methods of viewing material will require "critical point drying" which is done with a separate machine that should be located nearby. Critical point drying is a method of dehydrating tissue prior to examination in a SEM. The machine shows the pressure to temperature ranges where solid, liquid and vapor exist. The boundaries between these phases meet at a point on the graph called the triple point. Along the boundary between the liquid and vapor phases it is possible to choose a particular temperature and corresponding pressure, where liquid and vapor can co-exist and hence have the same density. This is the critical temperature and pressure.

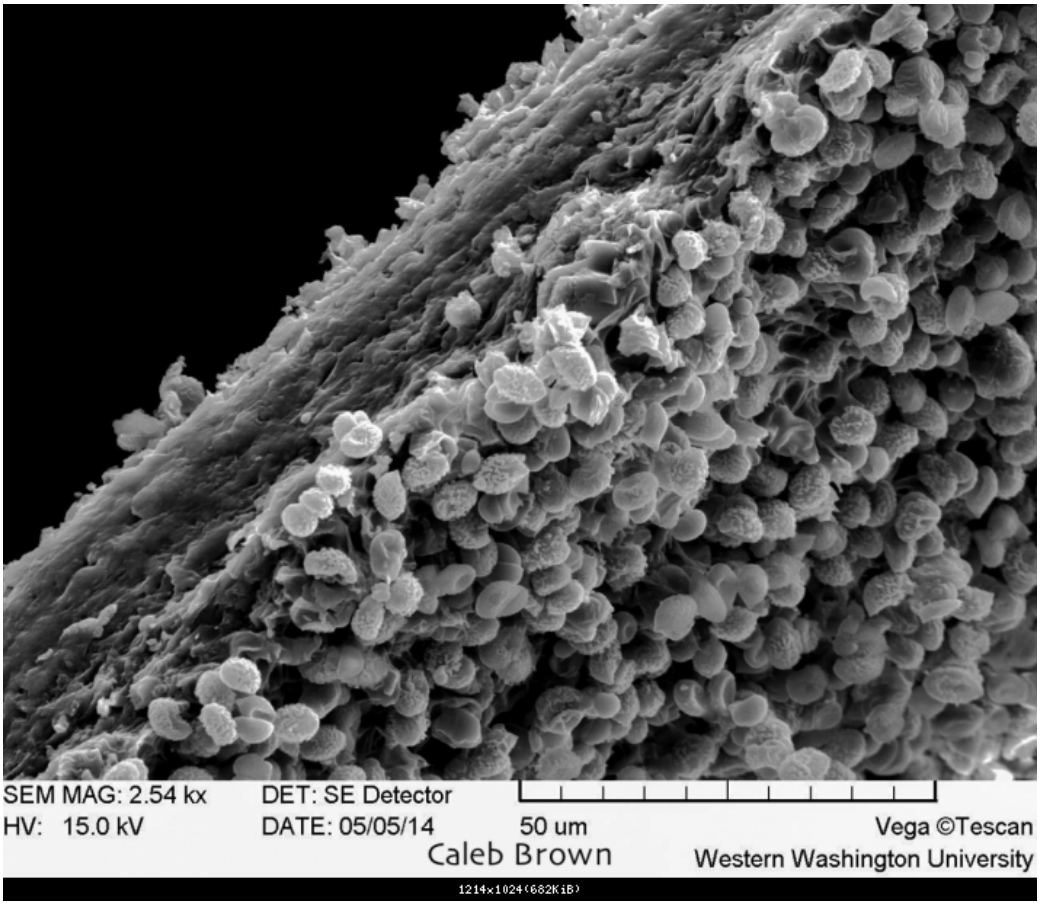
Below: A *Gymnopilus viridans* cross section courtesy Caleb Brown at low magnification



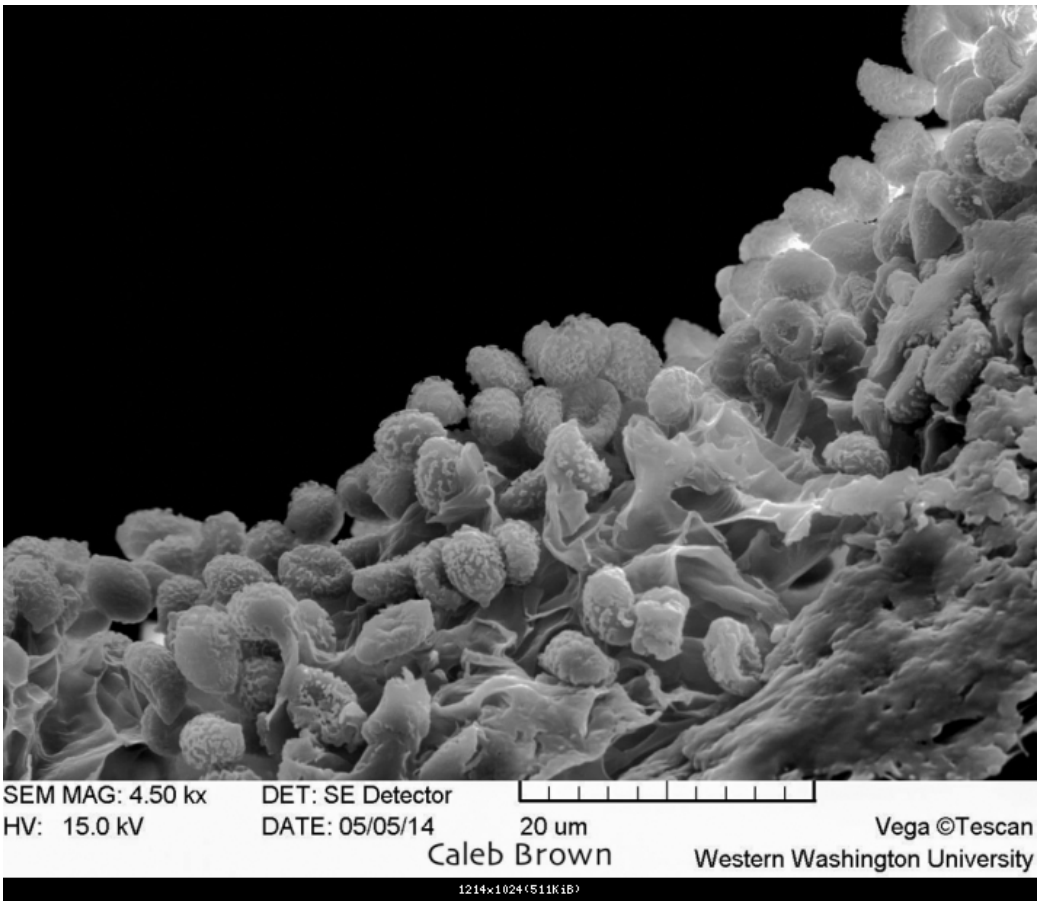
Below: A zoom of the same cross section onto a single gill



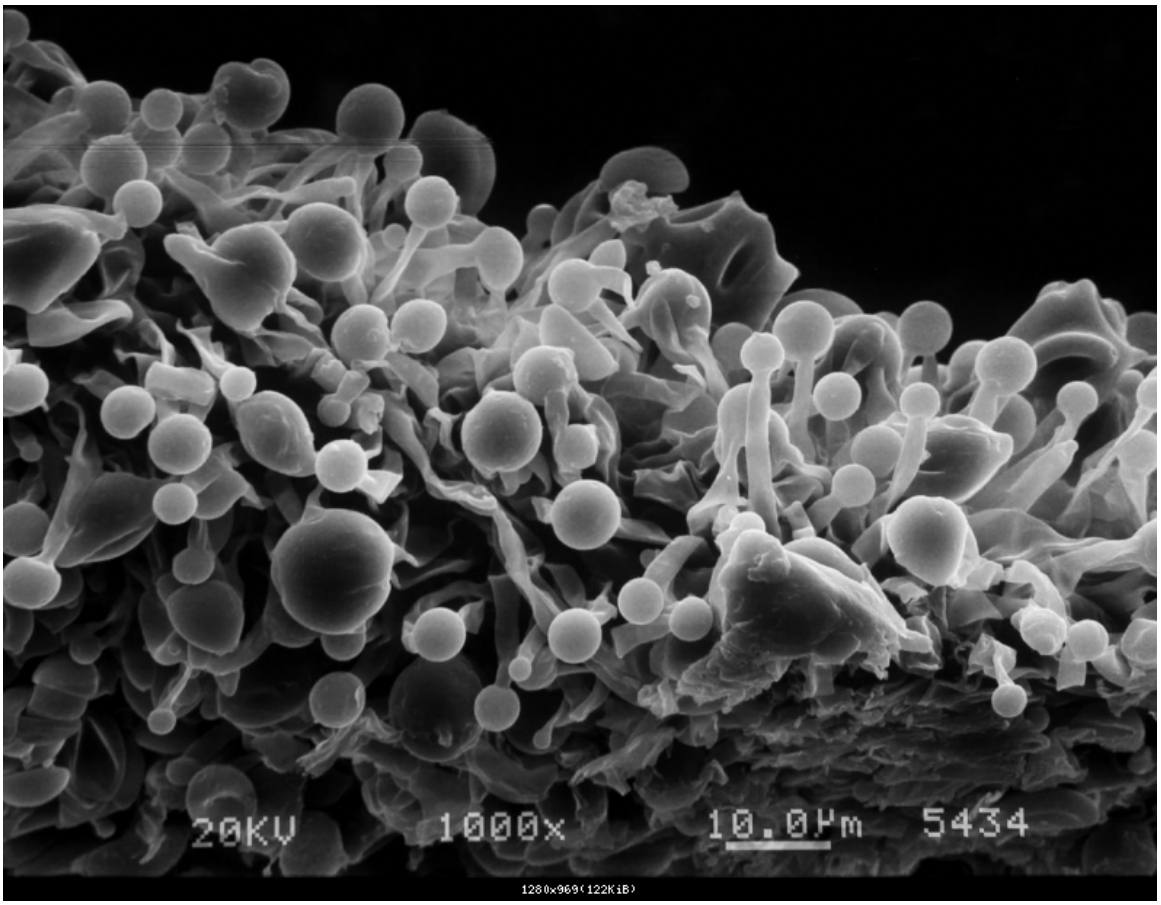
Below: At closer magnification the spore ornamentation becomes visible (View this M.O. Observation #144598)



Below: At even closer magnification (4.50 kx) courtesy Caleb Brown



Below: And finally, *Psilocybe aztecorum* cheilocystidia photographed by Mycologist and Travelling Lecturer Alan Rockefeller



Moving Beyond Typical Microscopy & Into Cell Components (Ultrastructures) via S.E.M.

"Light" microscopes will allow you to view and measure all that is necessary in mushroom identification. For those of you interested in moving beyond these features and into the more specific molecular details, here's an extremely fast touchdown.

Advances in microscope design have produced the "fluorescence microscope" (again that's spelled *fluorescence microscope*). Using special stains, greater details can be seen. These microscopes are generally much more expensive than compound light microscopes. Odds are, unless you have the resources and the will power, you'll end up asking for help from a college, university, or lab. Read about it on Wikipedia: http://en.wikipedia.org/wiki/Fluorescence_microscope

A university (or college) or a laboratory may alternatively provide limited access to a SEM (Scanning Electron Microscope), TEM, or a confocal model. New "benchtop" (like desktop) versions of SEMs are starting to appear on the market. In time, they could become slightly more affordable. A scanning electron microscope uses electrons instead of light to create an image. An electron has a much shorter wavelength than light in the visible region of the spectrum which gives a much, much higher magnification range. Some models can go up to 100,000x!

Ultrastructure SEM Microscopy in Spores

Nuclei

Chromosomes from a distance

Plasma

DNA from a distance

Proteins

Enzymes

Viewing DNA up close, as well as atoms, genes, etc.....**xyz**

Ultrastructure SEM Microscopy in Hyphae

Septum

Lipid Body

Vacuoles

Endoplasmic Reticulum

Crystal

Ribosomes

Nucleus

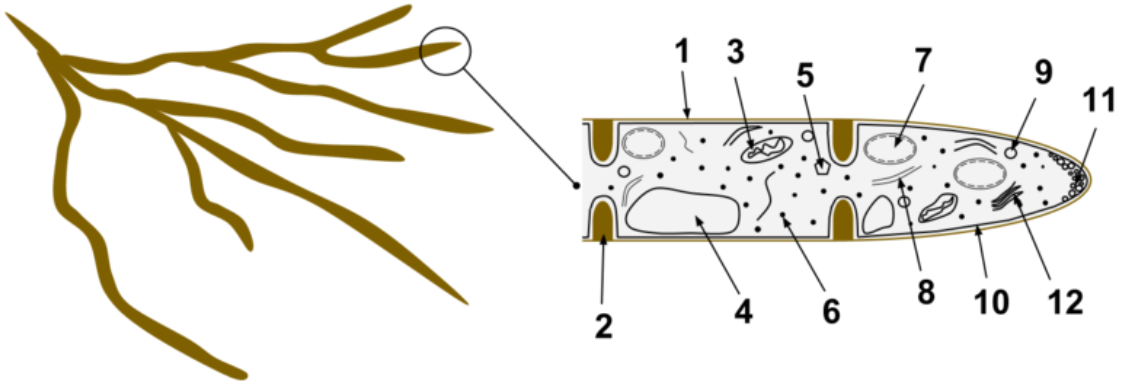
Mitochondrion

Golgi Apparatus

Hyphal Wall

Plasma Membrane

Vesicles



Courtesy Wikimedia Commons

1- Hyphal wall 2- Septum 3- Mitochondrion 4- Vacuole 5- Ergosterol crystal 6- Ribosome 7- Nucleus 8- Endoplasmic reticulum 9- Lipid body 10- Plasma membrane 11- Spitzenkörper/growth tip and vesicles 12- Golgi apparatus[/size]

Ultrastructure SEM Microscopy in Basidia

xyz

Nuclei (Fused)

Nuclei (Separate)

Ultrastructure SEM Microscopy in Cystidia

xyz

Endoplasmic Reticulum

Free Ribosomes

Golgi Apparatus

Cisternae

Specialized Secretion Mechanisms

Septal Pore

Apical Crystals

Spindle Pole Body

Vesicles

Vacuoles

Endomembrane System

Organelle-Free Zone

Connection to Hyphae

Stains and Methods for Observing Organelles within Spores, Cystidia, Hyphae, and Basidia

Organelles are specialized subunit within a cell that have a specific function, and they're usually separately enclosed within a lipid bilayer. The name *organelle* comes from the idea that these structures are to cells what an organ is to the body (hence the name). Nuclei, vacuoles, and mitochondria are all examples of organelles. They can can sometimes be seen (depending on the method and microscope) by utilizing the appropriate stain.

Stain preparation for observing nuclei:

Stain for granules:

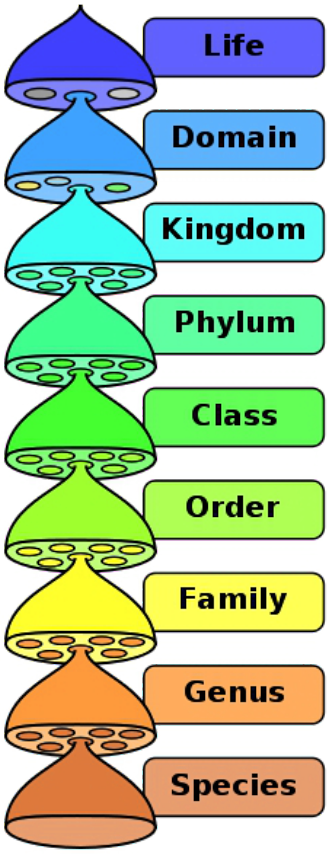
Stain for cell walls:

Stain for wall incrustations and deuteroplasmas:

Glycogen and polysaccharides:

Species Concepts

The "species concept" is indeed a concept - something that humans have applied to the natural world in order to understand life forms. In biology, the term "species" is one of the basic units of biological classification - and a taxonomic rank.



Above: The biological classification system courtesy Wikimedia Commons

There are several species concepts. The two most popular are the "biological species concept" and the "DNA (genetic) species concept." However, a species concept has many complicated aspects. One species concept that works well for one life form such as birds, may not at all apply to fungi or gilled fungi.

The Biological Species Concept

The biological species concept defines a species as members of populations that actually or potentially interbreed in nature, not according to similarity of appearance. Although appearance is helpful in identifying species, it does not define a species in this concept. Mating studies, which may extend beyond the practical outcome of natural reproduction in a wild-type setting, would be required in order to apply the biological species concept to fungi, including gilled fungi.

The DNA (Genetic) Code Species Concept

There are various genetic species concepts in terms of the allowed genetic variance(s) within a species and the coding region(s) selected to determine the species. In fungi (as of 2012) the DNA (genetic) species concept is applied when scientists and mycologists use the official DNA barcode to compare collections in order to determine each species. The current barcode is the full ITS region which is composed of the partial 18S rRNA, ITS1, 5.8S rRNA, ITS2, and partial 28S rRNA areas (depending on the ITS barcode region limits accepted for the study). Please note that other barcodes are used to determine species using the genetic species concept including: CO1, COX1, EF1 Alpha, RPB1, RPB1-intron 2, RPB2, 18S, 25S, Small Subunit ribosomal RNA, and Large Subunit ribosomal RNA, as well as a multi-locus approach.

The Phenotype Species Concept

This concept is visual and holds that a species is a set of organisms that look similar to each other and distinct from other sets.

Unified Species Concept(s)

A unified species concept combines two or more concepts in order to achieve the most accurate definition (limits) for a specific species. With regard to gilled fungi there are currently five popular unified species concepts:

The Macroscopic And Microscopic Species Concept

This concept combines the phenotypic description with the microscopic description (spores, cystidia, etc).

The Macroscopic And Microscopic Species Concept With The ITS Barcode

This concept combines a phenotype description, microscopy, and a genetic sequence on the ITS barcode.

The Macroscopic And Microscopic Species Concept With The Full Genome

This concept combines a phenotype description, microscopy, and a genetic sequence of the entire genome of a collection.

The Macroscopic And Microscopic Species Concept With Specific Regions of DNA

This concept combines a phenotype description, microscopy, and a genetic sequence of any desired area for study such as CO1, COX1, EF1 Alpha, RPB1, RPB1-intron 2, RPB2, 18S, 25S, Small Subunit ribosomal RNA, or Large Subunit ribosomal RNA.

The Macroscopic And Microscopic Species Concept With The ITS Barcode And Chemical Analysis

This concept combines a phenotype description, microscopy, genetic sequence on the ITS barcode, and chemical analysis comparison using methods such as liquid chromatography-tandem mass spectrometry (LC-MS/MS) for popular chemicals such as muscarine, amatoxins, etc.

The Distance Between Two Or More Species & The Variation Within Each Species

In an important conversation between Dr. Cornelis Bas and Dr. Rod Tulloss, Bas casually proposed a minimum three (3) differences in order to describe a new species that bared great resemblance to one or more species. Please note that these three (3) differences were proposed when mating studies had either not yet been performed or were inconclusive. While this "rule of three differences" is considered outdated and overly conservative by some mycologists, it is the basis for the discussion below.

In biology (i.e. the study of life itself) we are working within species concepts. One biologist (or mycologist) may use more demanding criteria for species delimitation while another biologist may use less demanding criteria. Our aim in taxonomy must be to present the most accurate and complete understanding of a particular species using any and all methods and concepts available to us.

Taxonomy and formal descriptions of species must include the following modern day minimum criteria:

1. Complete descriptions of all macroscopic characters (See list of macroscopic characters uses in taxonomy)
2. Complete descriptions of all microscopic characters (Compare to list above of microscopic characters with taxonomic value)
3. Mating study analysis (Compare to characters above)
4. Chemosystematics (Chemical Characters With Taxonomic Value)
5. DNA sequences at a minimum of the current official barcode (the complete ITS barcode region) and when possible, full genomic DNA sequences
6. Comparison of all macroscopic, microscopic, chemical, DNA, and mating compatibility studies within the genus

The above six-step approach should provide the zealous and detail-oriented mycologist with a sufficient set of criteria to consolidate or separate species. Bas's three difference rule is helpful but does not include a published, highly detailed distinguishment within each of the three differences.

Macroscopic Variation (Phenotypic Variance)

Based on weather, habitat, nutrition, human intervention, and a wide range of other important factors, a mushroom species can visually vary substantially from specimen to specimen and from collection to collection. Rather than describing a species based on one specimen or one collection, it is ideal, whenever possible, to study not only multiple specimens, but multiple collections. This is true not only for plain site (macroscopic) observations, but for microscopic, genetic, and chemosystematic studies. Please review the section "Macroscopic Characters with Taxonomic Value" for assistance in describing plain site features.

Microscopic Variation

It is traditional for some mycologists to allow for more variation macroscopically than microscopically. This is in part due to the time and effort required to accurately perform microscopy not only on one or several collections of a specific species, but by taking the time to perform microscopy on the appropriate number of collections to discover the true microscopic variation in a given species. It is common to read formal descriptions of mushrooms which provide macroscopic measurements of a mushroom species' total height and the diameter of its cap, but I have learned that the size of each collection of a species can vary tremendously. Microscopically, it is plausible to suggest that species may not have the same variance, but that variances are seen, particularly in regard to length and width of spores. For a list of helpful microscopic features worthy of every formal mushroom description, please see the section titled "Microscopic Characters with Taxonomic Value."

DNA Full Genome And ITS Barcode Variation

For the last several years the official DNA identification sequence that has been compared between fungal species has been the ITS barcode, a comparatively small piece of DNA coding in relativity to the complete, full genome DNA code. As we advance as a planet, I believe it is inevitable that we will choose to describe and delimit species based on the full, complete DNA genome. How important this will be for world health care cannot be understated.

Combined Macroscopic, Microscopic, And DNA Sequence Variance

In moving forward with formal identification, it should be noted that all species be described using all macroscopic, microscopic, and genetic observations. The three sets of data combined form the basis for the most accurate and intuitive species descriptions ever published.

Full Circle With A Mushroom's Life Cycle

There are some exceptions to the typical life cycle, so this example can be considered for many gilled mushrooms. Starting with an adult mushroom body, the gills have basidia with their haploid, asexual spores. These spores are ejected, sometimes reaching suitable ground (substrate) and suitable conditions (temperature, humidity, precipitation, etc) in which to grow. With access to water (and sometimes the addition of sugar and salt) a typical spore can initiate cellular creation through the germ pore, developing a single cell of hypha which continues to duplicate more hypha cells (hyphae). This can occur with two or more spores separately and their hyphae - when compatibility allows - can enjoin, forming one mycelium network. In this instance two mating types (ie two hyphae strands) connect, with each one having half of the genetic material to form a "whole" mycelium capable of producing a new mushroom when the appropriate conditions occur. (Note than some species can have highly abundant amounts of different mating types - making this discussion even more complex). The mushroom body begins with the creation of one or more hyphal knots in the mycelium which develop into primordia. In many occasions mycelium can live for years (sometimes centuries*) in highly unfavorable fruiting conditions - awaiting the right environmental trigger to produce healthy mushrooms. In this sense, the mycelium is the true species or life-form, and the mushrooms produced from it are merely a product or extension of the mycelium.

*http://www.scientificamerican.com/article.cfm?id=strange-but-true-largest-organism-is-fungus

FAQ

I'm buying a binocular microscope. Does this mean I need two reticles instead of just one?

No. In a binocular microscope there will only be one reticle in one of the lenses.

I bought a reticle (separate from the eyepiece) and I need instructions to install it into the eyepiece.

Depending on the eyepiece you own, you should be able to simply take the eyepiece out of the tube then turn it upside down. (Try not to get your fingerprints on the glass parts). Place the reticle inside so it's sitting flat, and in deep. Then insert the retainer ring (there are different types - some are solid and some are open-ended and flexible) so it prevents the reticle from moving. It's a fast and simple process if the ring goes in smoothly. More on this: http://www.microscopeworld.com/reticles.aspx

If I buy a binocular or trinocular microscope how should I connect a digital imager (microscope camera)?

Whether you are using a monocular, binocular, or trinocular microscope the imaging device only goes into one eyepiece. If it's binocular it can go in either the left or the right. You can always take the camera out and look through both eyepieces directly if you want to. If you're using a trinocular scope, just connect the camera at the single, upright eyepiece tube.

How can insects and similar life forms be cleaned out of fresh material?

The best method I've found is to immediately place all collections into a good dehydrator. Once the mushrooms are dry (approximately 12-24 hours later at 120 degrees) you'll notice a mass of insects have also dehydrated, many of them having fallen out of the hyphal tissue. There will still be massive amounts of spores, microscopy can be performed, and the collection(s) will be ready for storage in an herbarium. Ceremonial Curandera Maria Sabina used to take fresh mushrooms, as I understand it, and burn heavy amounts of an herb. She would hold the specimens in the smoke for a little while until the insects fell out. I'm not sure how practical or effective this is, and it seems more in tune with ritual than anything. Final note: I have tried placing fresh mushrooms that were insect-rich in the freezer, thinking that would kill them off. I was not only wrong about that not working, but the mushrooms were not in good shape for microscopy after doing that.

How do mycologists draw accurate representations of what they see through a microscope?

A microscope drawing tube (or camera lucida) is sometimes utilized. This creates an image of the specimen onto paper and the image is traced by the artist/mycologist.

My microscope camera (digital imager) has a built-in reduction lense. Does this change how I calculate the magnification (x number)?

No. Unless the manufacturer has told you to do so, go by the magnification number they tell you the camera/imager is set to.

What megapixel level is best or at least recommended for microscope cameras/imagers?

Megapixels can be important but at the end of the day you want to be able to say you have a crisp, clear picture. Check out the reviews of others who have tried the camera/imager. Some that are as low as 2.0 megapixels can - with the right microscope - produce good enough images for you to be happy with the product. You may be surprised how little clarity is added by having a higher megapixel camera.

What is the benefit of using a phase contrast microscope instead of a light (bright field) microscope?

Phase contrast microscopes alter the way light passes through a specimen through "phase shifts" of light. Phase contrast microscopy is particularly important in biology, as it reveals many cellular structures that are not visible with a simpler bright field microscope. These structures were made visible to earlier microscopists by staining. This required additional preparation which killed the cells. The phase contrast

microscopy made it possible for biologists to study living cells and how they proliferate through cell division. Sometimes the phase contrast image subjectively looks better than a bright field image due to the details visible.

What is the difference between achromatic objectives, plan objectives, infinity objectives, infinity plan objectives, and phase contrast plan objectives?

Achromatic objectives show an image that is flat across 70-85% of the field of view, while Plan objectives are flat across 90-100% of the field of view. Therefore Plan objectives are superior to achromatic objectives because you can see more and see it clearly. Infinity objectives, including infinity plan objectives, are designed specifically for infinity tube systems - and they have to match properly. Phase contrast objectives (used with a phase contrast microscope) reveal detail in transparent specimens without resorting to the use stains. This makes the phase contrast microscope one of the most used tools for observing living cells. Some microscopes may be good candidates for phase contrast kits in order to upgrade them.

I want to buy Congo Red stain, but which version is used in mycology?

Congo Red 1.0% Aqueous Solution. (If this is not available a very good alternative is: Congo Red Indicator 0.1% (w/v) aqueous solution. CAS No. 573-58-0 reagent).

What is the best staining agent for gilled mushrooms?

This depends on what cells you wish to view and perhaps even the microscope being used. It also depends on the species being worked upon. In general, I think most mycologists would accept Congo Red as a good general staining agent, later mounted in 3% KOH (97% distilled water).

What is the difference between a light microscope (bright field) and a darkfield microscope?

Bright field microscopy gives a lit-up view because of transmitted white light, i.e. illuminated from below and observed from above. Darkfield illumination is used to enhance the contrast in unstained samples. It works by illuminating the sample with light that will not be collected by the objective lens, and thus will not form part of the image. This produces a dark, almost black background with proper light illuminating the specimen. The darkfield system uses an opaque disk to block the central light from the condenser, only allowing marginal rays to illuminate the specimen. The result is a bright image against a dark background.

How should I handle requests to perform microscopy by various collectors?

For most microscopy requests I would request a couple of criteria up front:

A. The collection was photographed, in fresh condition, well enough to place it into a proposed genus (before or after microscopy is performed).

B. The photographs of the hydrated collection, accompanied with notes from the collector are posted online.

Have they undergone verifiable liquid gas chromatography? Yes or No. This should be listed on the collection when alkaloid content is possible.

For mail, the collection should first be properly dried and sealed in a plastic bag. "Identification request" written on a note should be included taped onto the outside of the ziplock and near the specimen. Once the ziplock has been zipped, it is best to have a protective layer like a small amount of cardboard (wrapped around it with tape) to protect the material from handling. A short note should be included with the link (or the Mushroom Observer observation number) to the collection and, if desired, a second method to contact the collector.

In collections which have a possibility of possessing an alkaloid, only a half of a dried pileus (with its gills) should be needed (if concerns arise) - assuming it is well taken care of and the gills are in good condition. If possible, a full collection representing the full characteristics of the species should be sent.

International shipping will need a little form describing the contents of the envelope. A good example: "Dried sterilized herbarium specimens."

What happens to cheilocystidia and pleurocystidia when they dehydrate?

Most gilled mushrooms are roughly 90% water when they're freshly harvested and in prime condition. That's why they get so small after they fully dry. The same size reduction process that occurs to the overall mushroom definitely impacts the size (and visibility) of both cheilocystidia and pleurocystidia. During the drying process, some cystidia will literally fall over (initially) like a cut down tree (only in a more elastic way). Others will swiftly begin reducing in size, sometimes becoming capable of shrinking back into the gill trama. Subtle changes to appearance will also occur.

What happens to spores when they dehydrate?

Some spores can shrink or change shape when drying. When possible, compare spore shapes and sizes between freshly collected spores from newly harvested mushrooms to rehydrated spores that have fully dried.

Can microscope slides be cleaned and re-used?

Absolutely. Colleges encourage students to remove the cover slip(s) and discard that portion because they usually just break during cleaning, but the slide itself can be rinsed in hot water and a little dish soap. Use good judgment with chemicals - not only what's getting on your hands but also what could go into your water supply.

How much genetic difference (in percent) does there need to be to accurately call a sequenced species "new" or different?

This question deserves our attention and it is very important. Until we have completed full genomic (as opposed to region) testing of every species of gilled fungi, and until we've sequenced not one collection but many collections of each species from many geographic sites known for its occurrence, we will be

lacking the ability to clearly, fully see base pair variation between species and within species. Until this important work has been performed, it seems proper that we discover more than a few DNA base pair differences in a region (or a few regions) before distinguishing species.

What is the ICN definition of a mushroom collection (or when a collection should be treated as two or more collections)?

The ICN does not make any special provisions for any particular group of organisms in its definition of a collection that may serve as the type of a name.

The relevant Article is:

8.2. For the purpose of typification a specimen is a gathering, or part of a gathering, of a single species or infraspecific taxon made at one time, disregarding admixtures (see Art. 9.14). It may consist of a single organism, parts of one or several organisms, or of multiple small organisms. A specimen is usually mounted on a single herbarium sheet or in an equivalent preparation, such as a box, packet, jar, or microscope slide.

The ICN Glossary notes that "gathering" is not defined in the Code, but provides the explanation: "used for a collection of one or more specimens made by the same collector(s) at the one place and time (Art. 8.2 and 8.3 footnote)".

Can hyphae from different mushroom species mate or have their mycelia merge to produce a new species?

In biology (the study of life) any species of mushroom is subject to the "biological species concept": "A species is a population whose members are able to interbreed freely under natural conditions." This means "natural" - not in the lab, not with a flow hood, etc. Mating studies cannot be done scientifically and accurately in a lab (ie that is not a natural occurring species). However, there are different species of mushrooms that will merge their hyphae on agar. This means a genetically unique species is possible, but more information on this topic is needed. This also means that it is possible for two different species to merge in natural settings and create a new species, but no studies that I am aware of have been published verifying that this has occurred.

Should there be some guidance as to how a mushroom collection is defined?

In my opinion, it can be helpful for a collector (and those involved in the study of a collection) to define what a collection is. For example, if a collector is at a particular site that is very small (say a 3 foot patch under a single Aspen tree) and the collector finds 12 scattered specimens of the same species at various ages, I would personally consider this one collection that should be consolidated for study. In contrast, if a collector goes to a second site where there are two trees approximately 30 feet from each other, and two of the trees each have 12 mushroms under them, I would consider them to be two separate collections (12 specimens in each collection). Each collector will have to decide while in the field how they will separate or combine specimens based on production from the same underground mycelium.

Can different species be crossbred to form new species?

New strains can be developed as seen in the following links:

http://www.google.com/patents/US5832659
https://www.google.com/patents/USPP2321 ... CD0Q6AEwAQ
https://www.google.com/patents/WO199400 ... CEQQ6AEwAg

Also review this link: https://www.google.com/patents/US201302 ... CE0Q6AEwAw

http://www.ncbi.nlm.nih.gov/pubmed/22515640

I believe new species can be produced in laboratory and natural settings. More studies are needed.

How can I access the official, written type description for the species I'm studying?

All species must be formally described in a peer reviewed scientific journal (in print or online). Google normally leads to Wikipedia for searches of this nature, and within the citations the original type collection may be listed with a link to the source. In a nutshell, keep searching until the listing comes up and it will be within reach soon after. You may have to purchase the book or journal if it is not available yet.

Can the color of a spore be different when viewed with a microscope - compared to viewing the color from the spore print?

Yes.

Is a spore likely to germinate under a coverslip?

Only if a slide has been created using spores that have been soaking in "liquid culture" water. Even then, it is a slow process and difficult to observe.

Are all mushrooms essentially identical in regard to the DNA, with just a region or two of small differences?

We are still waiting for complete genomic studies to be conducted in order to answer this question accurately.

How does phylogeny (the history of organismal lineages as they change through time) actually take place?

This question addresses the theory of evolution as well as speciation. Both terms should be reviewed at Wikipedia and then within a biology course framework. In brief, the following factors can contribute or cause "new" lineages: Adaptation, human-intervention, genetic drift, transcription errors, mutation, new genetic mating combinations, environmental or ecologically contributing factors, and unstudied factors that will inevitably be discovered as research continues. Think of every life-form as an abundance of software coding that can be slightly or dramatically altered. A bird that is forced into a habitat where in

needs a long beak to obtain food is suddenly forced to meet the physical demands in order to survive. Can the code change so the bird can grow a longer beak? Are there multiple ways to alter the code? Can the bird "will" its way into promoting code change? What can the bird do to change its code? All of these are questions are still being examined by biologists within the theory of evolution. In brief though, "new" species come from existing species (life begets more life and the variation of lifeforms) due to a number of different reasons. Over the course of days, weeks, months, years, decades, centuries, millenia, and long historic periods (hundreds of thousands of years) new species arise from extant species, forming the phylogeny that biologists continue to study.

What is the ICN and what purposes does it serve?

The ICN is an organization and a code (set of rules) dealing with the formal botanical names that are given to plants, fungi and a few other groups of organisms. It's full name is *The International Code of Nomenclature for algae, fungi, and plants*. The code and the official site are found here: http://www.iapt-taxon.org/nomen/main.php?page=title.

What are the ICN rules for deprecating, delimiting, and consolidating species?

Decisions on the delimitation of any taxon are taxonomic ones and are not a matter for nomenclatural rulings or recommendations. It is matter of evaluating the scientific research evidence as to whether two sets of organisms should or should not be recognises as species (or at any other rank). Nomenclatural rules do apply, however, when a species is no longer recognised or previously recognised species are united. The main rule is that of priority (Art. 11). The earliest name at species rank applicable to the combined species is the correct one (or, in the case of fungi, the earliest sanctioned name -- Art. 15),

What exactly is a species in mycology?

This is probably the most disregarded question in fungi taxonomy. I want to illustrate an example to answer this question. Picture you and a huge garden of *Stropharia rugosoannulata*. You brought your new camera to this garden and you took a picture. What exactly have you captured? The species? Or a representation of what you believe to be within the limits of what others define as *Stropharia rugosoannulata*?

In biology we learn that a species concept is a human-made concept. It is not something that Nature by itself clearly and constantly defines, otherwise we wouldn't have all these fun arguments when performing identification. Species are defined scientifically based on macroscopic appearance, microscopic observations, DNA sequences, and with other features in mind (ecology, chemical analysis, growth parameters, etc). But at the end of the day, just as we see a constant reshuffling of species changing names by authors - and even moving species into different genera - we are constantly left with a consensual description written by a trustworthy author or team of authors.

We also learn in biology that (in biology) a species is defined as a closed gene-pool (ie any species, in a natural setting, can freely interbreed within its own species). Is this definition being followed in mycology? I think mostly, yes. But there is this lingering temptation of bringing in agar-grown mycelium dishes and testing whether or not the hyphae will enjoin or form a division space of incompatibility. This is not a natural or valid method, of course, to test wild-type species breeding in a natural environment.

But it does beg the question, I think, how can we look into this without being unscientific?

Biologists have examined this question and the topic is actually called the *species problem*.

Currently, the best taxonomic method for identifying a species of mushroom is to note all macroscopic features, microscopic features, obtain a full genomic sequence (with initial focus on the ITS barcode), perform chemical tests (including chemosystematics), conduct mating studies, and finally to determine the variation of these five criteria within each species.

What are the ICN recommendations for placing a name on a newly described species?

Please review the ICN articles 32-45 at the following page http://www.iapt-taxon.org/nomen/main.php?page=art32 Also, though the name of a genus can be taken from any source, the recommendation is that it has a *Latinized* ending (recommendation 20A).

What criteria should be used to name a newly described species?

The true criteria are found within the ICN Melbourne Code recently published in print and online. Several chapters address the naming of new species, including fungi. Art. 32--45. Here's the link: http://www.iapt-taxon.org/nomen/main.php?page=art32

What do people mean when they say that some mycologists are "lumpers" while others are "splitters"?

A "lumper" has a broad species concept. In other words, they can more rationally support multiple phenotypes for the same genotype (ie the species will look variable enough that it looks like multiple species but it's actually the same species - genetically speaking). A "splitter" has a more narrow species concept. They hold more value in phenotype variation and would prefer describing multiple species even when the DNA is identical or darn near identical. In the end, this leads us to ask ourselves if we are in fact holding true to the biological species concept as it relates to a closed gene pool with regard to interbreeding (hyphae compatibility).

Is it possible for those who are studying DNA similarities to be "lumpers"/"splitters"?

Yes. Some mycologists may find that a 5-base pair difference within the ITS barcode region is sufficient to distinguish between two species (along with one macroscopic difference and one or more microscopic differences), while others may require further evidence. This question must be addressed in the near future and can be partially answered by testing hundreds of unique collections for each known species and determining the sequence variability of each species. In addition to ITS variability, full genomic variability must become known. Osmundson et al. (2013) discovered that the average ITS sequence is about 700 base pairs long. In addition, they published the difference in base pairs between species (1-71bp) and within species (0-71bp), as observed in their study published on PLOS One.

In biology we learn that the introduction of exotic (non-native) species can disrupt entire ecosystems and impact populations of native plants or animals. These invaders (invasive species) can adversely affect native species by eating them, infecting them, competing with them, or mating with them. Does this apply to gilled mushrooms?

Yes, but only one species of gilled mushroom comes to mind: *Armillaria mellea* and not in a consistent manner. See: http://www.na.fs.fed.us/spfo/pubs/fidls ... llaria.htm

For additional reading on this issue outside gilled fungi, begin reading http://www.nature.com/news/planetary-di ... 1.12174#b3

What mushrooms are currently on endangered species lists or red lists?

Please view the following: http://www.fieldmycology.net/Download/R ... _Fungi.pdf and note that a broader list that includes other fungi is being completed here: http://mushroomobserver.org/species_list/show_species_list/265

How important are gilled mushrooms to ecosystems and are they in need of conservation protection?

Gilled mushrooms are valuable to the human species for medicine, food, scientific studies, and to some individuals for "spiritual experience(s)." For these reasons alone, conservation of gilled fungi is crucial and as important as conserving any other life form on our planet. Ecosystems are also partly dependent upon them to break down decomposing material and to feed a wide variety of life forms including insects, animals, mollusks, plants (including trees), and beneficial bacteria. I would like to carefully note here that in my view the human species co-evolved with a variety of fungi, and notably with gilled fungi, including those species which are mind-altering. Things like language (which can transferred through a state of consciousness called glossolalia), false visions (scenes of the so-called future), true visions (scenes of the true future), auditory alterations (including auditory hallucinations which may or may not hold any truth whatsoever), and importantly - the full spectrum of religious experiences can also be more encounterable (including the common and uncommon "gods"), and uncommon and unexplainable experiences can also occurr. For these reasons and other reasons, it is adviseable to limit the over-availability and potential for misuse of such a potent product growing from our planet. I neither support nor condemn the use of such foods, but I strongly urge that they are not necessary and may lead to convincingly heavy burdens which the average individual may not be able to endure. Then again, with the amount of trouble that the current generation has been burdened with by all previous generations (including our most recent "parent generation"), it is highly likely that any honestly educated individual will find themself in the midst of very great burdens - without ever even learning about the mind-altering chemicals found in some species of mushrooms. Use caution, friend, and first learn the difference between Spirit and Soul, should such a difference matter. Let us not be unafraid to ask ourselves if all of the so-called "gods" and human belief in any of them could have come about through ritual and non-ritual usage of these and/or similar items. I will also note something that will probably anger some individuals who think of themselves very, very highly: There is such a thing as a post-Self (post Jungian) existence, bypassing the IAM state, overriding "The Voice And The Vision" known by one occult author who should be absolutely avoided and laughed off the library shelves. The level of responsibility at this state of consciousness is absurd and I wish it upon no one except those who can not only endure it, but those rare, rare individuals who have the strength and longevity to do things that are profoundly better for their planet than following a dark, sinister prophecy involving death, disease, natural disasters, fear-mongering, hells within hells, false heavens, and false hopes. Indeed, the human species needs people with good character who are not just good people - they do good in their life, sometimes profound good alongside their own demise.

Collections and living mycelium libraries are being preserved through a number of worldwide organizations, and many of these organizations are listed here: http://mycology.cornell.edu/fcollect.html

What is the appropriate method for picking a mushroom for taxonomic purposes?

As you know, mushrooms are the product of a living mass of hypha cells known as a mycelial species. When uprooting a mushroom body we do not want to damage the mycelium if it can be avoided. Having said that, some cell damage is inevitable. For taxonomic purposes it is necessary to have the full mushroom along with any attached basal mycelium or parts (cordons, fans, pseudorhiza, rhizomorphs, etc). Depending on the species and the condition of the specimen, you can grab the lowest part of the stem possible and gently, repeatedly wiggle the mushroom out of its substrate and mycelial mass. Sometimes it will be absolutely necessary to use your fingers to dig around the base of the stipe and then use a knife tip to push the mushroom up and out of its substrate.

What criteria guide a mycologist in the creation of an accurate phylogenetic tree of life for a particular genus or section?

This is now done with software and can even be performed using certain websites. There are a number of programs and websites available, and sometimes this tree information is provided at cost from the same lab performing the DNA sequencing of your collection(s). http://www.phylogeny.fr/, MEGA5 and others are available.

Can new species emerge within our lifetime?

Yes. There are two types of new species to consider: The first is a genuinely new species resulting in evolution (and this is based on science) which I'll explain in a moment. The second type is a newly discovered species that may have existed for awhile but was never discovered due to growing in an unexplored habitat or being so rare that no mycologist was given the opportunity to discover it.

In biology, a "species" is defined as: "a population whose members are able to interbreed freely under natural conditions." Each biological species is a closed gene pool, an assemblage of organisms that does not exchange genes with other species. To use a mushroom as an example, if I were to look at *Stropharia rugosoannulata* and consider this species' size, color, shape, its habitat and its microscopic features - even with the differences existing between specimen to specimen, I can accurately consider mushrooms paralleling these features to be *Stropharia rugosoannulata* if in fact the hyphae merge and do not create a barrier of incompatibility.

However, it is helpful to point out, while we're on the subject of what a species really is, that DNA studies now come into consideration. Recent studies have shown identical DNA between a number of groups of mushrooms - causing a bit of an identification cluster. What this means to me as a mycologist is I have a responsibility if I find a potentially undescribed (new) species. I have to perform DNA sequencing. Furthermore, it would be interesting if not supportive to verify mycelium compatibility in the event DNA matches another described species but clearly exhibits obvious unique features.

Mycelium compatibility is based on a natural setting, not a laboratory setting. Even with those most neutral approaches of working outdoors with found-in-nature spawn or specimens, and creating two separate grow beds side-by-side, one must question if this is a Natural (wild-type) approach to determining compatibility. Surely, anything more evasive in approach would extend beyond a natural approach.

Can mushroom mycelium become dormant (whether in a healthy & moist state or in a partially dry or dehydrated state) and later revive once proper moisture is provided?

A definition of dormancy is: Having normal physical functions suspended or slowed down for a period of time. This is absolutely true of fungi, including gilled fungi myceliums. One of the common causes for dormancy is simply cold weather in which a mycelium will stall its mycelial growth and at the same time produce no fruit bodies of mushrooms.

How can I contribute my observations in a way that is helpful to others?

There are many types of fungi that have still not been described. You can definitely help by looking for new types and photographing them and sharing your notes on sites that upload your information to biodiversity databases (ie EOL.org among others). This is actually easy work but it is very helpful to our planet on multiple levels. The best resource for uploading your data is currently http://www.mushroomobserver.org where most of the world's socially uplifting mycologists are congregating and sharing their observations. This site accepts all types of fungi and there are many students who are helping one another in the identification process.

Are gilled mushrooms the only life form that use spores to regenerate?

No. Spores form part of the life cycles of many bacteria, plants, algae, fungi (not just gilled mushrooms) and some protozoa.

Can spores survive and remain viable through interplanetary travel?

This is - at the present time - a "theoretical question" that is going to get a "theoretical answer." In order for spores to leave Earth and reach another suitable planet, a challenging journey would have to occur - or so it seems based on the science we currently have. Experiments have been designed to test spore survival in Space. In terms of a natural process of travel, spores would have to exit our atmosphere and go into deep Space and journey through potentially challenging environments. The same concept is true of spores travelling from another planet to Earth. They have to safely escape that planet's atmosphere, travel safely through highly challenging systems, and enter our atmosphere safely, eventually landing in suitable ground. Depending on the time frame the spores have lived (and remained viable), and depending on the shipping method (deep inside a temperature-controlled area of a meteor), I believe it is possible for them to travel. There may be other methods by which spores can travel as well (magnetic currents, gravitational low energy transfer, stellar winds, etc). However, spores can only handle so much challenge (and time) before they are destroyed or can no longer germinate. We know with certainty that meteors and debris not only make it through our atmosphere, but also to the very ground we walk upon. We also know there are other Earth-like planets out there. Could we be exchanging microstructures, some of which lend to the compatible exchange of lifeforms here on Earth?

More reading on this at http://en.wikipedia.org/wiki/Atmospheric_escape

How do basidia eject spores?

The spore(s) releases a small amount of sugar through its hilar appendage. Water condenses onto the sugar at the tip of the hilar appendage and forms a drop (known as Buller's drop). A thin film of water forms on the spore surface synchronistically. The developing Buller's drop grows so large that it causes the center of mass to move from the center of the spore down to the hilar appendage. The Buller's drop grows large to the point that it reaches the spore surface film water mentioned above. The drop then collapses and is merged with the water on the spore surface. This causes the center of mass of the spore to return back to its true center swiftly, and the area of connection between the hilar appendage and the sterigma is broken. The momentum generated by the collapsing water drop is enough to give the spore an acceleration of 25,000 times the force of gravity.

How many spores do mushrooms eject in ideal circumstances?

Under ideal environmental conditions, a single specimen of *Agaricus campestris* can release 31,000 spores each second, or 2.7 billion spores per day (Buller 1922). Each species and each collection (within a particular weather and environmental system) is likely to vary but more studies could be conducted to determine this.

Do mushrooms produce stem cells? (And by the way, what are stem cells?)

Stem cells are biological cells found in all multicellular organisms that can divide (through mitosis) and differentiate into diverse specialized cell types and can self-renew to produce more stem cells. Almost every cell formed by a fungus can function as a stem cell. The multi-cellular fruiting bodies of basidiomycete fungi consist of the same kind of filamentous hyphae that form a mycelium. Visible cellular differentiation is almost nonexistent. Mushroom primordia develop from masses of converging hyphae, and the pileus, gills, and stipe are clearly demarcated within the embryonic fruiting body long before the organ expands and unfolds through water uptake and cell wall loosening. Even in fully mature mushroom fruits every hypha retains its totipotency (i.e. the ability of cells to give rise to unlike cells and develop a new anatomical part or new offspring.)

Are hypha cell walls made of chitin?

The cell walls of hyphae are strengthened by fibrils of chitin (chitin is a nitrogen-containing polysaccharide). Fungal cell walls consist of various glucans and chitin.

What is a microtome and how is it used in microscopy?

A microtome is a tool used to cut extremely thin slices of material (ie sections). They're used very rarely in basic microscopy, but are used frequently in advanced identification. Microtomes allow for the preparation of otherwise impossibly thin sections for observation under transmitted light or electron microscopy. Different microtomes use steel, glass, laser or diamond blades depending upon the specimen being sliced and the desired thickness of the sections being cut. Reliable models are usually costly and

therefore mycologists almost always find alternatives, like a handheld razor blade. Colleges and universities may provide you with limited access.

Have you ever needed to rely on identifying microscopic features other than spores, cystidia, and basidia - in order to properly identify a collection?

Yes. The pileipellis structure and the presence or absence of clamp connections are helpful in ruling out certain species and ruling in others.

What temperature should mushrooms be dehydrated at if DNA sequencing will take place?

No more than 105 degrees is recommended, but it's within possibility to still get legible DNA coding when dehydrated above this.

Do some gilled mushrooms self-digest themselves in order to obtain nutrition or to increase their own decomposition?

zzz Autolysis (self-digestion) refers to the destruction of a cell through the action of its own enzymes. Some enzyme types are even capable of destroying cells of their same enzyme type.

Are mutations common in gilled fungi?

Yes. More studies should be conducted to determine why and when mutations occur.

When studying mutated specimens microscopically, have you seen a difference in the microstructure size or shape (as opposed to unmutated specimens of the same species)? What about a greater variety of microscopic cells?

ZZZ

How can I take a near-sterile or sterile spore print for laboratory processing?

If you are gathering a mushroom from the wild for reproduction in the laboratory avoid touching the gills and pick one or two pristine specimens. Immediately place them in a clean tupperware container and head back. Upon returning from the field, wash your hands thoroughly and use an unexposed sheet of typing paper or sheet of tin foil and place it on a clean, hard, flat surface. Get an additional tupperware container without the lid and clean it with ispropyl alcohol and paper towel. Set it upside-down on-top of the typing paper or tin foil. Get two sterile, unexposed microscope slides and handle them by the edges. Place them inside the tupperware area where you'll be doing the prints. Next, swiftly remove the stems from the mushrooms and place the caps on-top of the slides for no more than a couple of hours. Remove the caps from the slides at this point and leave the tupperware container over the slides for a couple days minimum so the spores can fully dry. They are now ready for agar work, or if the occasion arises, a flow hood could allow immersion straight into a sterilized liquid culture jar.

When mushrooms do not provide a spore print or they provide a very light spore print, is there an alternative method to obtain more spores?

Yes. Obtain a glass dish and clean it with paper towel wettened with rubbing alcohol. Clean two or more glass slides in the same manner and place them inside the dish. Take the pileus of each fresh specimen and place it on top of the glass slides accordingly. Prepare a water syringe after first boiling the water for a few minutes. Use this syringe to apply water to the top of the caps once each morning and once each evening for 3-5 days until the spore deposits are obtained. Remember to seal your glass dish with a lid at all times unless applying H2O. Distilled water is preferred over tap water.

Do myceliums experience dieback (die back)?

Yes. Mycelial dieback is a process in which a mycelium begins to die from the perimeter of its cell mass (dying inwardly) as a result of disease or unfavorable environmental conditions.

At what point can someone accurately attain a mushroom's identification to species level? (ie How can I know what species I've collected with 100% certainty?)

This is a question that poses more questions. Every year, a number of loyal and enthusiastic mushroom seekers return to their morel spots (*Morchella*mushrooms). I can easily imagine, even among those who have hunted them for decades, many hunters who simply did not know the species names of their collections. In fact, I am equally certain that some of these collections of morels will include two or more distinct species, but to a percentage of these seekers they are all "morels."

Even among all mycologists is a constant reshuffling within taxonomic consensus. In frequent occurrence, a competent and respected mycologist will initially identify a collection of mushrooms down to species level, only to (within hours, days, or weeks) relabel their collection with an entirely different species and genus. This begs the question, how do I know what I'm picking? My answer is this: Macroscopic and microscopic features must absolutely match the type description of the species used in which the species was named, then laboratory confirmation should take place through DNA sequencing.

This is not to say that macroscopic (plain sight) identifications cannot successfully be made. Indeed - they very well can be made, but in the case of scientific and taxonomic investigation, it is imperative for macroscopic, microscopic, and molecular studies to match the type description of the species in question.

Are mushroom spores in the air we breathe?

The air we breathe contains as many as 10,000 fungal spores per cubic meter. This number reflects all types of fungi.

Do all species of gilled mushrooms have cheilocystidia?

No. Some do not develop cheilocystidia.

Do all gilled mushroom species have pleurocystidia?

No.

Do all gilled mushrooms have basidia?

Yes, but there are "sterile" collections or sterile mushrooms within a collection which do not develop basidia. This is comparatively rare.

Does pleurocystidia occur on every gill of species that produce pleurocystidia?

Not always. Pleurocystidia can vary in frequency.

Can temperature impact the size and appearance of cystidia?

More studies are needed to verify this.

How many types of fungi exist on the Earth and of those that have been identified, how many are gilled mushrooms?

There is a wide estimate ranging from 1.5 million to 5 million species in the Kingdom Fungi (Blackwell, The Fungi: 1, 2, 3 … 5.1 million species? published in the American Journal of Botany), of which 100,000 fungi have been identified. Among those that have been identified, there are 13,000 gilled mushrooms as of January, 2013 (Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008 Dictionary of the Fungi 10th ed Wallingford, UK: CABI. p. 12. ISBN 0-85199-826-7).

What is the oldest identified gilled mushroom in the history of our planet Earth?

There are a few very, very old examples of gilled mushrooms found in amber (amber preserves not only mushrooms but a number of other types of life forms). The oldest examples that I currently am aware of is available for review here: http://www.amjbot.org/content/84/7/981.full.pdf

What is the oldest identified fungi in the history of Earth?

This question needs further supporting evidence and additional study. It is possible that *Prototaxites loganii* - an extremely sizable fungi - is the oldest fungi on record.

How many genera of gilled mushrooms are there?

This number is likely to dramatically change from the date of entry due to DNA sequences and new studies. As of 2008 there are 413 genera of gilled mushrooms.

How many gilled mushrooms have been described as of 2012?

Over 13,000 described species, along with five extinct genera known only from the fossil record. Many undescribed collections are awaiting formal scientific descriptions.

Do any science stores sell pre-made slides (permanent slides) of mushroom tissue for study?

There's at least two as of 2013: http://sciencekit.com/mushroom-microsco ... IG0021257/ and http://www.swift-microscopeworld.com/p- ... otany.aspx

What taxonomic features are observable in herbarium collections that have been kept for years, decades, or centuries?

Mushrooms that have been carefully harvested, dried, and stored will usually retain their microscopic features for hundreds of years. Type collections held in international (and local) herbariums are therefore worth performing microscopy on in order to provide the public with digital microscopic images of each collection.

What is included and excluded in DNA sequencing (in terms of genes and regions)? How much of the full genome is recorded and compared?

Different studies may include one or more regions of DNA or the full genome sequence. It is up to the mycologist(s) and the study being conducted. The official DNA barcode for fungi as of 2012 is the complete ITS region which is a very small part of the full genomic data.

Are cheilocystidia differentiated or undifferentiated cells?

Differentiated.

What cells are undifferentiated in a gilled mushroom body?

Any generative hyphae cells which microscopically fit the traditional definition of septate hyphae which have not taken on another form (shape) or a unique function. Examples of differentiated cells include spores, cheilocystidia, pleurocystidia, basidia, stipe cystidia (caulocystidia), basidioles, and spiral hyphae.

What are some classic examples of mutations of gilled fungi?

xyz [gallery insertion needed] ZZZ

Do individual cells (basidium, cystidia, etc) sometimes undergo mutation?

Yes, they do.

Will DNA sequences from a mycelium match the DNA sequence of the mycelium's mushrooms?

More studies are needed. Please review the following link: http://www.ncbi.nlm.nih.gov/pubmed/1184 ... t=abstract

How are mating studies conducted with regard to gilled mushrooms? Can a microscope be included?

ZZZ

So what species is truly the original, common ancestor of all mushrooms, and what life form developed it?

We still don't know. Full genomic studies must be conducted for all fossilized and thousands of living collections of gilled mushrooms. We should also sequence all herbarium collections.

Can gilled mushrooms be genetically modified and improved?

Yes - one patented process involves homokaryon transfer between spores: Publication number EP0707443 B1

Are hypha pluripotent cells?

Yes.

What causes differentiated cells to become differentiated in fungi?

To my knowledge this has not yet been answered scientifically and conclusively. This is probably one of the single most evolutionary pieces of information awaiting the human species (although I am writing here of differentiated and undifferentiated cells [and tissues] produced by the human genomes). I will wait for scientists to answer this question, and add only another item or two to this FAQ question. Imagine a mushroom's outer layers and travel through all of its layers (the pileipellis first, the pileus trama, the hymenium, the subhymenium, the gill trama, etc). What are the most common cell types and what are the original cell types that gave a path to other cell types? We know that mushrooms start with spores (which are differentiated cells when contrasted with hypha cells). Spores develope and can mate to generate mycelium (a mass of hypha cells). Whenever we find a group of cells or individual cells that match the basic microscopic appearance of these hypha cells in the mycellium, many mycologists tend to also refer to them as hypha cells. When we witness cell types that are distinguishable by shape, formation, and theoretical function, we tend to give them new names and no longer call them hypha cells (we call them spores, cystidia, basidia, basidioles, masses of specialized hyphae, layers, etc.). Was there an environmental growth paramater (too much sugar, not enough of a single protein) that transformed a layer of hyphal tissue, forcing it to become different in the next generation of cells?

What allows some hypha cells to remain undifferentiated?

ZZZ

Does pleurocystidia occur in every collection of a specific species known for having pleurocystidia?

No. The presence of pleurocystidia can vary between collections.

Can pleurocystidia emerge not only from the hymenephore layer but possibly the trama layer?

ZZZ

What medicines are obtained from gilled mushrooms?

Beta-glucans are obtained from *Lentinula edodes*. Lovastatin is obtained from four species of *Pleurotus*: *P. ostreatus, P. cornucopiae, P. eryngii, and P. sapidus*. Lentinula edodes provides Eritadenine (also known as “Lentinacin” or “Lentysine).” A number of supplements are also made from single and combined mushrooms to boost human immunity.

Is it possible to make an accurate stage micrometer instead of purchasing one?

It is not recommended, but you may be able to get relatively helpful measurements by following this guide: http://www.microscopy-uk.org.uk/mag/artoct02/hwmicrometer.html

Is gravitropism a factor in the development of gilled fungi?

Gravitropism (also known as Geotropism) is a turning or growth movement by a plant or fungus in response to gravity. It is a general feature of all higher and many lower plants as well as other organisms. http://www.youtube.com/watch?v=xLYeZKDv0Ig & http://www.fungimag.com/fall-2012-artic ... pismLR.pdf

How do mushrooms ingest food?

They secrete enzymes that break down nutrients and then absorb these nutrients. Fungi live by absorptive heterotrophy: they secrete digestive enzymes outside their bodies to break down large food molecules in the environment, then absorb the breakdown products through the plasma membranes of their cells. Absorptive heterotrophy is successful in virtually every conceivable environment. There are three main methods they do this and these terms have been coined: Parasitism, saprobism, and mutualism.

What gilled mushrooms have been used to restore an ecosystem, crops, or other biosphere health-related issues?

Not enough of our citizens (conducting citizen science and mycorestoration) have documented their projects. Most of the research done by Fungi Perfectiseems to have been performed with *Pleurotus ostreatus* (the oyster mushroom).

What relationship(s) do gilled mushrooms have with oxygen and CO2 (carbon dioxide)?

Mushrooms are similar to humans - more similar than they are to plants. Gilled mushrooms breathe in oxygen, like humans, and exhale CO2 (carbon dioxide). The nearby location of fungi (usually growing near plants and trees) provides plants with CO2. This CO2 is used through photosynthesis in the plants, which in turn causes the plants to "exhale" new oxygen. It is important to note that while mushrooms are exceedingly helpful to most of the Earth's ecosystems in breaking down organic matter, they do contribute to the overall carbon footprint of the Earth.

How do mushrooms metabolize?

The aim of a mushroom species when metabolizing is to change external substances (food) into a form

that can be used by the mycelium for the growth and continued life of that mushroom species. This process begins to be performed when a mycelium excretes enzymes outside its hyphae into the nearby material (wood, soil, etc), breaking down that material into digestible materials. The hyphal cell walls will then absorb these foods. **ZZZ**

What is apoptosis? Have any students of mycology observed apoptosis in mushroom cells?

Apoptosis is the process of programmed cell death that may occur in multicellular organisms. Biochemical events lead to characteristic cell changes and death. More studies are needed to understand apoptosis in gilled mushrooms.

Do any gilled mushrooms grow in the ocean or in fresh waters?

There is one fresh water gilled mushroom that I am currently aware of, which probably means there are others I still need to learn of: *Psathyrella aquatica*, although I have not yet heard of one growing in the ocean. There are approximately 444 species in the Kingdom Fungi that grow in salt water (http://en.wikipedia.org/wiki/Marine_fungi). There are over 600 species of fungi that grow in fresh water (http://link.springer.com/article/10.102 ... 75?LI=true).

What relationship do gilled mushrooms have with plants (including trees)?

Gilled mushrooms provide natural CO2 to plants and trees during the process of photosynthesis. They also provide nutrients as a result of processing dead or decaying matter. Several types of plants, including those producing garden vegetables, benefit from a variety of mycorrhizal fungi, including certain species of gilled mushrooms. Mycorrhizal mushroom myceliums can establish relationships of shared chemistry in a system known as mutualism. In this mutualistic system, mushroom mycelium gives something chemically beneficial to the plant or tree, while the mycelium also receives nutrition from the network of roots of the same plant or tree. Saprotrophs live in the top layer of soil and digest dead matter (for instance decaying wood), breaking up molecules into individual components – converting proteins into amino acids and starches to simple sugars, and freeing up elements such as nitrogen – that plants rely on for growth. Mycorrhizal fungi have an even closer bond with plants, living among their roots and converting older forms of organic matter into nitrogen and phosphorus for the plants. The same plants feed these fungi a steady network of sugars obtained from photosynthesis.

Why do mushrooms grow on wood chips or mulch?

Decaying wood provides lignin and carbohydrates, a common food source for mycelium.

What relationship do gilled mushrooms have with bacteria?

Bacteria exist bountifully throughout much of the Earth, including on plants, fungi, and animals. Mushrooms have soft flesh which is easily bruised, helping bacteria such as *Pseudomonas* species to spread. These *Pseudomonas* species can cause brown blotches on the caps. A condition known as mushroom soft rot can occur as a result of the bacterial species *Burkholderia gladioli* (=*Pseudomonas marginata*). *Burkholderia gladioli* is a species of aerobic gram-negative rod-shaped bacteria that causes disease in both humans and plants. It can also live in symbiosis with plants and fungi and is found in soil,

water, the rhizosphere, and in many animals. *Burkholderia gladioli* is divided into three pathovars: *gladioli*, *allicola*, and *agaricicola*. *B. gladioli pv. gladioli* causes gladiolus rot, *allicola* causes onion bulb rot, and *agaricicola* causes soft rot in mushrooms. *Pseudomonas tolaasii* is a species of gram-negative soil bacteria that is the causal agent of bacterial blotch on cultivated mushrooms (such as *Agaricus bisporus*). It is known to produce a toxin, called tolaasin, which is responsible for the brown blotches associated with the disease. In a DNA study on *Pleurotus* substrate the following bacterial genera were identified: *Pseudomonas* and *Sphingomonas* at startup and *Bacillus*, *Geobacillus*, *Ureibacillus*, *Pseudoxanthomonas*, and *Thermobispora* at the end of partial composting, (and finally several genera of *Actinobacteria*, *Thermus*, *Bacillus*, *Geobacillus*, *Thermobacillus*, and *Ureibacillus* in the mature substrate). More studies are needed to not only identify bacteria that grow on gilled mushrooms but also to know the role(s) of each species and to understand any transformation of each species.

How can bacteria be viewed with a microscope?

You'll want access to a water immersion phase contrast microscope. Bacteria are sometimes between 0.5 and 5 microns. Plus, most bacteria are colorless. Objectives used to observe bacteria cells must have extremely good resolution and high numerical aperture. Another way to observe living bacteria is with dark field illumination (dark field microscopy). It is useful to use oil immersion dark field condensers. Instead of using phase contrast, bacteria can be stained with dyes and viewed using dark field microscopy. This process, however, kills the bacteria cells. Please note that it is possible to see some species of bacteria using a compound light microscope but it is very difficult.

xyz

Above: A series of bacteria cells from the genus zzz.

What relationship do gilled mushrooms have with soil and microscopic organisms common in soil?

Saprotrophs live in the top layer of soil and digest dead matter (for instance decaying wood), breaking up molecules into individual components – converting proteins into amino acids and starches to simple sugars, and freeing up elements such as nitrogen – that plants rely on for growth. ZZZ

What types of razor blades or sectioning tools should I buy?

The Personna double edge stainless steel blades (pictured above) will work fine. Alternatively, American Safety .009 razors or Astra superior platinum double edge razors will also work well. Note: The Personna and Astra double edge blades snap in half to form two razors for every one whole razor, giving you 200 razors per box instead of 100. This can be done while they are still in the package and it's completely safe and very easy. If you want extra protection for your hand, you can wrap the top layer of the dull end in masking tape, otherwise they can be used without the addition of tape. If none of the blades mentioned above are available, a surgical scalpel and #10 blades with curved edging can be used.

Another excellent tool to add to your gear: Mycology forceps [bent, curved]. After making a preparate cut-out, a gill cross section, or any other type of section, bent forceps provide the means to transport tissue from the sectioning area onto a fresh, clean slide. Alternatively, you can clean the razor used to make the section - or use a fresh razor - and move the tissue to a fresh slide.

How should mushrooms be harvested?

There are generally two different scenarios for harvesting: 1. For personal consumption (or for others) 2. For study, including microscopy. For the first scenario, the mycelium underground should be regarded with great care. The mushroom(s) can be harvested using a clean knife by slicing the base of the mushroom just above the ground or a little higher up on the stipe. If you want to study the mushroom, though, you'll want the full body of the mushroom, including the base of the mushroom. To harvest in this way, there are a couple of tried and true methods that will work. If the mushroom is tough and healthy, try handling it by the base and very slowly begin to wiggle it. After 20-90 seconds, the mushroom should become free - sometimes after more time. If wiggling does not work, or if the mushroom is frail, use a tool (or piece of wood or stone) and carefully dig around the base of the mushroom, mindful that the

base may be wider than the stipe. Once the base is fully revealed, go ahead and begin the wiggle method. That should work.

Are there types of fungi or other organisms that can grow on gilled mushrooms?

Yes. Gilled mushrooms can be colonized by other types of fungi as well as bacteria and viruses. A good instance of this is found in the edible "lobster" mushrooms which is actually two or more types of gilled mushrooms (*Russula brevipes* and *Lactarius piperatus*) being colonized by *Hypomyces lactifluorum*, a parasitic ascomycete (fungi).

What relationship do mushrooms share with insects?

Below: Two images of an insect travelling along a gill

Mushrooms are frequently used as food sources, housing structures, and nursery sites for a number of insects.

Do gilled mushrooms produce male and female gametes?

When we talk about gametes we normally begin with the starting discussion of human men producing sperm (a gamete) and human women producing eggs (a gamete). Together, these form a new human. With gilled mushrooms the concept of gender is useless and does not apply. Instead, the term "mating types" is used with the instance of two mating types - each containing half the genetic information necessary to make a primary mycelium. (See definitions of primary, secondary, and tertiary mycelium). Many mushrooms have more than two mating types (thousands!), but in each instance the purpose is the same: To get two compatible mycelia (hyphae) together (ie cell fusion) and to get their nuclei near each other within each individual hypha cell. Eventually these two nuclei connect (fuse!) while in a basidium - and the separate again to make spores of individual (haploid) hyphae mating types.

Are gilled mushrooms produced through meiosis, mitosis, or a combination of meiosis and mitosis?

First, for the sake of expanding our knowledge powerfully, let's go over the definitions of meiosis and mitosis. This is a conversation about how cells make more cells and what's in those cells. Meiosis is a type of cell division that results in two "next generation" cells - each with half the chromosome number of the parent cell. Mitosis, in contrast, is a type of cell division that results in two "next generation" cells - but they are complete and identical to the parent cell (ie they are not lacking half the genetic material of a whole individual as seen in meiosis). To repeat these definitions more clearly, meiosis is the process of one cell generating two addition cells (capable of being called gametes) with one having 50% of the

cellular data and the other having the missing 50% of the cellular data (ie they are not identical or complete in the way the parent cell is). Mitosis, in contrast, is the process of one cell generating more cells of identical content (100% of the individual versus 50% and 50% in two individuals).

Do mushroom spores or hyphae have sex?

There are two stages of reproduction that are relevant to this question: An asexual stage (in which spores self-germinate), and a sexual stage (in which multiple hyphae strands - ie mycelium - enjoin and become one network, eventually leading to the creation of a new mushroom. This is similar to the exchange of gametes in that cellular information and content is being exchanged and merged - for the purpose of reproducing a new specimen. Gilled mushrooms reproduce sexually when hyphae of different mating types meet and fuse together.

Do all gilled mushrooms produce haploid spores, or do some produce diploid spores?

Gilled mushrooms produce sexual and asexual spores. Let's focus on one mushroom in particular for a moment to keep it simple. We'll use *Agaricus arvensis*, a choice edible mushroom. *Agaricus arvensis* spores create hyphae - two types of spores and thus, two types of hyphae. Type one has half the genetic code needed to produce a flush of mushrooms. Type two has the other half of the code. These two hyphae types join and mate, forming one mycelium and eventually mushrooms. When two types of hyphae join to form a mycelium this is the diploid mycelial state of this species. Check out http://www.mushroomthejournal.com/great ... el137.html for more info!

Are gilled mushrooms eukaryotes?

Yes. (A eukaryote is an organism whose cells contain complex structures enclosed within membranes).

Are gilled mushrooms diploid or haploid?

It depends what stage of growth and what part of the mushroom. Haploid means there is half of the genetic material needed to make a new specimen. Diploid means it contains all the genetic material needed to make a new specimen. Gilled mushrooms have a haploid growth stage (spores contain only half the genetic material at any one time), and a diploid stage (two different hyphae from two different spores can contain both needed sets of genetic info and merge together).

How long can spores stay alive? (Is it possible for ancient spores, buried underground for thousands of years, to germinate in the right conditions?)

There is a possibility in my opinion that ancient spores to germinate. I just don't know what the conditions would be. Bacteria spores (or at least one type) can survive and remain viable for over 7,000 years according to the article, *Spores Still Viable after 7,000 Years*. Mushroom spores have not been tested (and results published) in this length of time, but we do know that spores have been successfully germinated (with viable mycelium and fruiting bodies) after decades have past. Age does become a factor and will inevitably reduce the viability of spores. A mycologist working with very old material should consider Stamets' method from **Mycelium Running** (page 131).

What is the longest term method for keeping spores viable while being stored?

More methods will likely be developed in the future. One reliable method is to take a spore print directly on a microscope slide and then store the slide in a sealed ziplock bag in a refrigerator. It should remain viable for several years, possibly much longer.

I realize bacteria can sometimes be found when performing microscopy. How large is the average bacterium?

0.2-2 microns (Up to about 20 microns in maximum length) - within view of a light microscope at high magnification.

I realize bacteriophages and other virus cells could be seen if enough microscopy is performed. How big are they on average?

24-200nm (nanometers) for phages. 100nm for virus, with a range of 10-300nm. Most viruses cannot be seen with an optical microscope so scanning and transmission electron microscopes are used to visualise virions.

Why do many mushrooms grow on wood chips or wood?

Mushrooms are decomposers and wood is one of their natural food sources. They obtain lignin and carbohydrates from many types of wood.

How do gilled mushrooms evolve in theory?

Above: *Psilocybe semilanceata* in the field. Courtesy Caleb Brown.

◊ **Natural Selection**

Theory In Summation: Organisms possessing traits that are better adapted to their environment tend to survive longer and transmit more of their genetic characteristics to succeeding generations than do those that are less adapted. The adapted, surviving organisms tend to produce more offspring than those less adapted, transforming the characteristics of a population over time, thus accounting for the process of evolution. In addition to the above factors, Natural Selection proposes the following: There is variation in traits within a single species and comparitively between species.

Natural Selection is a theory proposed by Charles Darwin (1809-1882 - with theory published in 1859). This theory states that species have differences between one another (particularly differences in physical appearance). This theory also states that predators of a species (and other environmental factors) impact how one or more species multiply and proliferate. One species may suffer little in terms of predation, while a different species may succumb to predators and environmental factors more easily. Those species which are less doomed to predation and which can better withstand their environment - while also successfully procreating their phenotype based on their genotype - will become more prevalent.

An example in the Kingdom Fungi (These aren't stated as facts and are simply to illustrate an example): A gourmet mushroom, *Lyophyllum shimeji*, is hunted and eaten by humans far more than the deadly poisonous *Galerina marginata*. Humans find the Lyophyllum mushroom aesthetic, the aroma pleasant, and the taste delicious. Contrastingly, humans find the Galerina to be unpleasant looking, unpleasant in aroma, bitter in flavor, and it is known to cause death. Over time the quantity of *Lyophyllum*

shimeji reduces because it is hunted and consumed extensively, while *Galerina marginata* is left alone and allowed to proliferate more abundantly due to less or no predation. In addition, this population of *Lyophyllum shimeji* is fruiting from tiny mycelial masses in the ground - ever so rarely - but the *Galerina marginata* is more commonly found with mycelium and fruitbodies covering fallen logs in great frequency and abundance. Even moreso, the mycelium of Galerina is hyperproductive, ever-expanding, and has several mating types. Over time, the Galerina species goes on to far outpopulate the Lyophyllum species and in each of the successive Galerina populations there are found the genetic-based traits of general health, adaptions to survive environmental conditions including predation and competition for resources, and the "desire" and act to again reproduce boldly.

◊ **Genetic Drift**

Analogy with mushrooms growing in a mason jar

The process of genetic drift can be illustrated using 20 living mushrooms in a mason jar to represent 20 specimens in a population. Consider this jar of living, sporulating mushrooms as the starting population - even the first generation of its species to ever exist. Half of the mushrooms in the jar are orange and the other half are blue, (yet all of these specimens are the same species). Both colors correspond to two different alleles of one gene in the population. In each new forthcoming generation the organisms reproduce at random. To represent this reproduction, randomly make note of a mushroom specimen from the jar. We'll call it a parent. Now, in a separate, second jar add a new mushroom specimen (2nd generation) of the same color as its "parent." (The selected mushroom specimen remains in the original jar.) Repeat this process until there are 20 new mushrooms in the second jar. The second jar then contains the second generation of "offspring," consisting of 20 mushrooms of various colors. Unless the second jar contains exactly 10 orange mushrooms and 10 blue mushrooms, a random shift occurred in the allele frequencies.

Repeat this process a number of times, randomly reproducing each generation of mushrooms to form the next. The numbers of orange and blue mushrooms picked each generation fluctuates: Sometimes more orange, sometimes more blue. This fluctuation is analogous to genetic drift – a change in the population's allele frequency resulting from a random variation in the distribution of alleles from one generation to the next.

It is even possible that in any one generation no mushrooms of a particular color are chosen, meaning they have no offspring. In this example, if no orange mushrooms are selected the jar representing the new generation contains only blue offspring. If this happens, the red allele has been lost permanently in the population, while the remaining blue allele has become fixed. All future generations are entirely blue. In small populations, fixation can occur in just a few generations.

◊ **Evolutionary Selective Pressure**

Evolutionary selective pressure is any phenomena which alters the behavior and fitness of a living organism within a specific environment. It is the driving force of evolution and natural selection, and it can be divided into two types of pressure: biotic or abiotic. *Biotic pressures* are organisms living within the same ecosystem that interact with the impacted organism. *Abiotic pressures* are non-living factors making impacts within the organism's environment. Abiotic factors can include light, wind, temperature,

humidity, lack of rain, increases in nitrogen, or escalation of the carbon-14 isotope. All of these factors can interact with the organism to provide opposition to its continued survival.

◊ **Phenotype Plasticity**

Phenotypic plasticity is the ability of an organism to change its phenotype in response to changes in the environment. Fundamental to the way in which organisms cope with environmental variation, phenotypic plasticity encompasses all types of environmentally induced changes (e.g. morphological, physiological, behavioral, phenological) that may or may not be permanent throughout an individual's lifespan. The term was originally used to describe developmental effects on morphological characters, but is now more broadly used to describe all phenotypic responses to environmental change, such as acclimation or acclimatization, as well as learning.

◊ **Common Ancestory**

The theory of evolution includes the proposal of common descent, which is to say that multiple species share the same ancestor *and* there is a "family" tree - a *phylogenetic tree* - showing a lineage between all species, all genera, all kingdoms, and all life. To summarize what this means in a simple statement: Species beget new species and within all known lifeforms is a common code, a shared ancestor and shared "relatives." All current and former living organisms on Earth share a common DNA heritage - with each individual lifeform being the descendant of a single, original species - even a single individual in whom life was first granted.

Gilled fungi probably evolved from non-gilled fungi which were land-based. These land-based, non-gilled fungi probably evolved from water-based (oceanic and non-oceanic) non-gilled fungi. These oceanic and non-oceanic water-based fungi probably developed as a result of speciation (the creation of new species) around approximately 1500 million years ago, judging by current studies of the fossil record. Somewhere within this timeline and transformation, mycorrhizal fungi developed with plants. With the help of a 410 million year old rock (the Rhynie chert), scientists have observed fungal hyphae entering plant material, demonstrating the presence of ancient fungal decomposers and mycorrhizae.

The strange and wonderful, terrestrial genus Prototaxites is also observed in our fossil record and dates back approximately 420 to 370 million years ago. This genus is currently thought of by some as fungal in classification. It possessed tubes and was 25 feet tall and 3 feet wide. If it was fungal or partially fungal (in the same sense that lichens are partially fungal), and it was this old and this large, it may have played a vital role in the forthcoming evolution of mushrooms.

◊ **Habitat Fragmentation**

Habitat fragmentation describes the emergence of discontinuities (fragmentation) in an organism's preferred environment (habitat), causing population fragmentation and ecosystem decay. Habitat fragmentation can be caused by geological processes that slowly alter the layout of the physical environment, which may be one of the major causes of speciation. Habitat fragmentation can also occur by human activity such as infrastructure development, deforestation, and even human pollution. Such activities can alter the environment rapidly and causes extinctions of many species.

◊ **Evolutionary Loss(es)**

We can look at species over time and witness inheritable evolutionary losses and evolutionary gains. More precisely, we are talking about the inheritable alteration of DNA code (ATGC, etc) by losing code, gaining code, and/or changes to code. Evolutionary loss is a subtraction of part of DNA code. A theoretical example of evolutionary loss has been published regarding the lack of forcible discharge of spores in non-basidiomycete fungi. The term was also used in a 1977 paper entitled "Evolutionary Loss Of Useless Features: Is It Molecular Noise Suppression?"

◊ **Evolutionary Gain(s)**

Just as we and all species appear to be susceptible to evolutionary loss, we and other species can also add DNA coding to our genome. A gain does not always imply a beneficial gain, as if a gourmet mushroom now tastes better since genetically modifying it. Rather, it is the gain of additional code - for better, for worse, or in neutrality.

◊ **Habitat Gain**

Opposite of environmental loss, some species inevitably experience habitat gain. The human species is foremost among all species on our planet that have experienced habitat gain. This has had huge impacts across the Earth, which has been addressed by a number of writers. It would be poignant to ask one's self: What has the human species done to the health of other species and to the health of Earth itself as a whole, singular organism.

◊ **Habitat Loss**

Habitat destruction (habitat loss) is the process in which natural habitat is rendered functionally unable to support the species present. In this process, the organisms that previously used the site are displaced or destroyed, reducing biodiversity. Habitat destruction by human activity is mainly for the purpose of harvesting natural resources for industry production and urbanization. Clearing habitats for agriculture is the principal cause of habitat destruction. Other important causes of habitat destruction include mining, logging, trawling and urban sprawl. Habitat destruction is currently ranked as the primary cause of species extinction worldwide. It is a process of natural environmental change that may be caused by habitat fragmentation, geological processes, climate change or by human activities such as the introduction of invasive species, ecosystem nutrient depletion, and other human activities

◊ **Long-Term Evolution**

Long-term evolution describes inheritable, stable changes (mutations) to the genetic code of a population or species, which may or may not impact macroscopic or microscopic features. These changes can be interpreted as *pretty darn permanent*, for lack of a better phrase. Speciation can occur as a result of long-term evolution, while still allowing for the possibility of the former species to co-exist in its latest form.

◊ **Short-Term Evolution**

Short-term evolution describes a finite (limited) number of changes (mutations) to a limited number of genotypes within a population or species. In this example a trait that has evolved is not *pretty darn permanent*, but rather can last for a generation or many generations.

◊ **Convergent Evolution (Independent Evolution)**

Convergent evolution is the process whereby organisms not closely related (not monophyletic), independently evolve similar traits as a result of having to adapt to similar environments or ecological niches. Convergent evolution describes the creation of analogous structures that have similar form or function, but that were not present in the last common ancestor of those groups.

◊ **Survival Of Those Who Produce The Most With The Best Adaptations**

Everyone in the current era should be familar with the theoretical phrase "survival of the fittest." The person who coined this term (Philosopher Herbert Spencer) influenced Charles Darwin's fifth edition of *On The Origin Of Species*, which would include the phrase. Many people have used this phrase incorrectly, applying it to human reproduction and human toughness, as if to justify one group of people's success in comparison to another - no matter what means were used. The biological concept of "fitness" is defined as reproductive success. From Darwin's theory, it is best interpreted as "survival of the form that will leave the most copies of itself in successive generations," and "better designed for an immediate, local environment." This is to say that the fit (those who have developed successful offspring) have a greater propensity toward successful survival and reproduction than the less fit (those who have achieved less successful and less numbered offspring).

◊ **Devolution**

Devolution, de-evolution, or backward evolution is the notion that species can revert into more "primitive" forms over time. Evolution is incorrectly thought of by some people as a constant state of natural progression and improvement. In theory, however, species can exhibit decline and loss. Instead of developing new and inheritable attributes of health, far less desirable traits can evolve within a species including inheritable genetic disease, phenotype mutation (unhelpful physical changes), and the return to old code (which could have a number of impacts from susceptibility to environmental factors to mating difficulties, and beyond). In short, devolution is degeneration; the evolutionary decline or loss of a function, characteristic, or structure in a species - and such traits are inheritable to forthcoming generations.

How large in terms of base pairs is the average gilled mushroom's genome?

This is still being studied and could be answered in the current or forthcoming decade. The common button mushroom sold in grocery stores, *Agaricus bisporus*, was sequenced using the full, complete genomic DNA code and was found to contain 30,387,844 base pairs. Imagine for a second comparing a DNA bar code (a small piece of genomic code instead of the complete code) between two or more species or many individual specimens within a species. I wish more people would imagine and realize the potential value of this comparison, particularly for the sake of human health.

How is sulpho-vanillin (sulphovanillin) prepared or can I just purchase it?

You should prepare the solution after obtaining 100% pure vanillin crystals and 98% sulphuric acid (which is also spelled *sulfuric acid*). The solution sulphovanillin not only lasts for an extremely short period of time (minutes, maybe longer) it also can produce color changes that are very short-lived. It is a combination of vanillin and sulphuric acid. It requires preparation before use or during the actual preparation of your slide. Sulphovanillin can generate very important and differentiating reactions. One method to use sulphovanillin is to first create a slide using water as the mounting liquid on your mushroom cells. Cover it with a cover-slip. Add some crystals of vanillin at one side of the cover glass and put a small drop of H2SO4 on these crystals. Be sure that there is contact between the water of the preparation and the dissolving reagent and that there is no acid on the cover glass. The liquid should begin to mix with the water under the cover slip. If need be, use a tissue or napkin on the opposing side of the cover slip to create a vacuum-like effect. If you want to make a small amount in a container, use nearly 65% sulphuric acid and 35% vanillin crystals. The sulphuric acid when purchased should be 98 % sulphuric acid. The vanillin are crystals of pure vanillin and you dissolve only a few crystals so that the solution becomes yellow, but few enough that all are dissolved in the drop of sulphuric acid. A second formula (solution) is 5mg. of vanillin crystals dissolved in 6ml. of 80% sulphuric acid. Some people make it up on the slide by adding a tiny amount of vanillin crystals to a drop of 80% sulphuric acid and stirring with an acid resistant tool (e.g. glass or stainless steel). A pale straw-colored solution is the aim. It is important to dissolve all the crystals otherwise they can crack the cover slip when you press it down. Some mycologists may prefer a small amount (5 or 6 drops) in a watch glass and use that. Use great care when handling sulphuric acid as it is extremely corrosive! One mycologist ruined a favorite t-shirt at a recent Russula workshop by burning several holes in it! Never attempt to make up dilute acid from concentrate unless you are sure of what you are doing. The dilution process can cause the acid to boil and spit! Dispose of unused sulphovanillin promptly in an environmentally astute manner, including any related slides. You will find that the stained material lasts only a short while anyway - roughly 10 minutes - as the strong acid quickly destroys it.

Glossary for Identification of Gilled Mushrooms

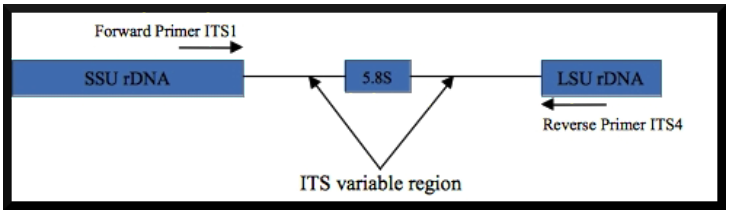
Note: Several of the definitions are taken from the 2012-2013 edition of http://www.Wikipedia.Org and used through their Creative Commons Attribution/Share-Alike License or their GFDL.

3': Three prime. When reading DNA the 3' is the "3 prime" position. It is also the position on the particular molecule involved while reading code.

5': Five prime.

5'-nLSU-rDNA: 5 prime nuclear Large ribosomal RNA SubUnit ribosomal DNA.

5.8S Region: Found within the ITS rDNA region. The 5.8S ribosomal RNA (5.8S rRNA) is a non-coding RNA component of the large subunit of the eukaryotic ribosome and so plays an important role in protein translation. It is transcribed by RNA polymerase I as part of the 45S precursor that also contains 18S and 28S rRNA. Its function is thought to be in 5.8S rRNA ribosome translocation.



18S Region: 18S ribosomal RNA (abbreviated 18S rRNA) is a part of the ribosomal RNA. The S in 18S represents Svedberg units. 18S rRNA is a component of the small eukaryotic ribosomal subunit (40S). 18S rRNA is the structural RNA for the small component of eukaryotic cytoplasmic ribosomes, and thus one of the basic components of all eukaryotic cells. It is the eukaryotic nuclear homologue of 16S ribosomal RNA in Prokaryotes and mitochondria. The genes coding for 18S rRNA are referred to as 18S rDNA. Sequence data from these genes is widely used in molecular analysis to reconstruct the evolutionary history of organisms, especially in vertebrates, as its slow evolutionary rate makes it suitable to reconstruct ancient divergences. The small subunit (SSU) 18S rRNA gene is one of the most frequently used genes in phylogenetic studies and an important marker for random target polymerase chain reaction (PCR) in environmental biodiversity screening.

28S Region: 28S ribosomal RNA is the eukaryotic nuclear homologue of the prokaryotic 23S ribosomal RNA; this is the structural RNA for the large component of eukaryotic cytoplasmic ribosomes, and thus one of the basic components of all eukaryotic cells.

Abaxial Side (Synonymous with Ventral Side): The convex side of a spore that faces away or outward from the imaginary axis of the basidium.

Abbe Condenser: A two-lens sub-stage condenser located below the stage of a microscope and functions to collect light and direct it onto the object being examined. Its high numerical aperture makes it particularly suited for use with most medium- and high-magnification objectives.

Aberrant Spores: In some attempts to measure spores it may be found that there are a small population of different sized spores (for instance >1.5 times longer than the normal ones). If the mycologist determines these spores to be abnormal she/he may exclude them from measurement and note that this was done and the reason for doing so.

Abruptly Adnexed: Notched gill attachment in which the gill attachment is adnexed and the gill edge curves abruptly upwards towards the stipe but makes contact with the stipe in a straight line.

Abruptly Bulbous: Refers to the shape of the stem's base. A bulbous stipe base with a distinct margin and an upper surface either attached at a right angle to the stipe or sloping upward to the stipe; the upper surface is not shaped like the edge of a saucer as in a marginate-depressed bulb.

Absorptive Heterotrophy: Fungi live by *absorptive heterotrophy* (ie they secrete digestive enzymes outside their bodies to break down large food molecules in the environment, then absorb the breakdown products through the plasma membranes of their cells). Absorptive heterotrophy is successful in nearly every environment.

Acanthiform: Shaped like a thorn.

Acanthocyte (Acantha, Pl., Acanthocytes): Stellate cells found on the hyphae of fungi of the genus *Stropharia*, including the nematode-killing species *Stropharia rugosoannula*. Cells with finger-like or arrowhead-shaped projections.

Acanthophysis: 1. Hyphoid with numerous branches along its surface such that it resembles a bottle brush. 2. Cystidia that are club shaped with almost spiny outgrowths.

Accession Number: 1. The unique number given to each new acquisition as it is entered in the catalog of a institution or herbarium. 2. A unique identifier given to a biological polymer sequence (DNA, protein) when it is submitted to a sequence database. (Please note that once someone provides a collection to an herbarium it may be termed "accessioned" or a curator may say it is in the process of accessioning a collection).

Acicular (Aciculate): Needle-like. Having a long, slender point.

Acongophilous: Spore wall does not absorb (or have impact by) congo red stain.

Acrophysadelic: Tissue consisting of connective hyphae and abundant, large, terminal, inflated elements (acrophysalides).

Acrid: Taste is intensely sharp and burning. Peppery.

Aculeate (Synonymous with Trichiform): Cutting; pointed. Cystidium which are tapered so that only the very basal portion is relatively swollen. The entire cystidium is slender and shaped like a spine.

Acuminate: Tapering from inwardly curved sides off to a point.

Acute: Pointed. Tapering off to a sharp point.

Acyanophil: Lack of blue staining of spores with cotton blue.

ad int. (ad interim, ad int,): Means "in the meantime" or "temporarily".

Adaxial Side (Synonymous with Dorsal Side): The concave side of a spore which faces the imaginary axis of the basidium. In an asymmetrical spore the dorsal side is concave in side view, whereas the fat or pot-bellied portion of the spore is always on the ventral side of the spore.

Adnate: Lamellae broadly attached to stipe.

Adnexed: 1. Narrowly attached to a stipe or stem. 2. Lamellae rounded towards stipe.

Aerial Mycelium (Aerial Mycelial Hyphae, Aerial Hyphae): The portion of mycelium that grows upward or outward from the surface of the substrate.

Aeruginascin: Aeruginascin or N,N,N-trimethyl-4-phosphoryloxytryptamine is an indoleamine derivative

which occurs naturally only within the mushroom Inocybe aeruginascens. Aeruginascin is the N-trimethyl analogue of psilocybin. It is closely related to the frog skin toxin bufotenidine (5-HTQ), a potent 5-HT3 receptor agonist, and has been found exclusively in *Inocybe aeruginascens*.

Aequihymeniiferous: This term was first used by mycologist Arthur Henry Reginald Buller in 1909. Having basidia maturing all over the surface of each lamella at once, not leaving patches of less matured spores.

Aerial Mycelium (Aerial Hyphae): The portion of mycelium (hyphae) that grows upward or outward from the ground surface of the substrate, and from which propagative spores develop in or on characteristic structures that are distinctive of various genera.

Aff.: Abbreviation for *affinis* or *species affinis*. A Species affinis (Affinis, abbreviations: sp. aff., Aff., or Affin.) is a species related to but not identical with the named species. It is used in between genus and species.

Agar (agar-agar): A product derived from seaweed, valued for its gelatinizing properties, and commonly used to solidify nutrified media for sterile tissue culture. A gelatinous substance obtained from various kinds of red seaweed and used in biological culture media and as a thickener in foods. I've heard this word pronounced ahh-grr, ae-gar and uh-gar, but either way the word conveys itself to the listener.

Agaric: This term has meant different things to mycologists over the past two centuries. The term agaric had traditionally referred to *Agaricales*, which were defined as "those fungi with gills." Given the discoveries of the past several decades, those two categories are not synonymous (although there is a very large overlap between the two groups).

Agaricaceae: The Agaricaceae are a family of basidiomycete fungi and includes the genus Agaricus, as well as basidiomycetes previously classified in the families Tulostomataceae, Lepiotaceae, and Lycoperdaceae. The family contains 85 genera and 1340 species.

Agaricales: 1. The fungal order Agaricales, also sometimes known as gilled mushrooms (for their distinctive gills), or *euagarics*, contains some of the most familiar types of mushrooms. However, non-gilled fungi have been placed in the order Agaricales, and some gilled fungi (including Russulas) have been placed out of Agaricales. The order has 33 extant families, 413 genera, and over 13,000 described species, along with five extinct genera known only from the fossil record. 2. "Agaricales," the taxonomic order used for centuries to hold mushrooms with gills, turns out **not** to include species of Russula and Lactarius, for example, but does include the Bird's Nest Fungi and many Puffballs (source http://www.mushroomexpert.com/agaricales.html).

Agaricineae: Gilled mushrooms.

Agaricoid: Mushroom-forming.

Agaricomycetes: Agaricomycetes is a class of fungi. The taxon is roughly identical to that defined for the Homobasidiomycetes by Hibbett & Thorn, with the inclusion of Auriculariales and Sebacinales. It includes not only mushrooms but also most species placed in the deprecated taxa Gasteromycetes and Homobasidiomycetes. Within the subphylum Agaricomycotina, which already excludes the smut and rust

fungi, the Agaricomycetes can be further defined by the exclusion of the classes Tremellomycetes and Dacrymycetes which are generally considered to be jelly fungi. However, a few former "jelly fungi", such as Auricularia, are classified in the Agaricomycetes. Agaricomycetes, as of early 2013, include 17 orders, 100 families, 1147 genera, and 20951 species.

Agaricomycetideae: Agaricomycetidae is a subclass of mushrooms placed in the phylum of Basidiomycota. The name *Agaricomycetidae* was also named by Locquin (1984) but because his publication did not contain a Latin diagnosis it is considered invalid under the International Code of Nomenclature for Algae, Fungi, and Plants.

Agaricomycotina: The subdivision Agaricomycotina, also known as the hymenomycetes, is one of three taxa of the fungal division Basidiomycota (fungi bearing spores on basidia). The Agaricomycotina contain some 20,000 species, and about 98% of these are in the class Agaricomycetes, which comprises most of the fungi known as mushrooms, including the bracket fungi and puffballs. Species in the Agaricomycotina that are not Agaricomycetes include the jelly fungi, certain "yeasts", ear fungi, and others; these are gathered together as the classes Tremellomycetes and Dacrymycetes.

Agaricus: In his three volumes of *Systema Mycologicum* published between 1821 and 1832, Elias Fries put almost all of the fleshy, gill-forming mushrooms in the genus *Agaricus*. He organized the large genus into "tribes," the names of many which still exist as genera to this day. Agaricus is now known only as a genus.

Alate: Having wings; winged. Having winglike extensions or parts; winged.

AL - D: The average L - D (Note that "L - D" is the length minus the diameter of measured spores).

Alder: Alder is a difficult-to-find-wood when searching for bulk. Smaller quantities are, however, easily obtained in the barbecue sections of many stores. Alder sawdust can be obtained from landscaping companies. Small and fine slices of alder are soaked for no more than 72 hours in tap water or distilled water, then added to dry equal amounts of alder sawdust in a filter bag. After impulse sealing, the bag(s) must be pressure cooked at 15PSI for 90 minutes.

Alethocystidia: Cystidia without deuteroplasm.

Aleuthocystidia: Exosecretion cystidia.

Alignment(s) (Sequence Alignment): Refers to phylogenetic trees (trees of species, trees of populations, trees of genes). A sequence alignment is a way of arranging the sequences of DNA, RNA, or protein to identify regions of similarity that may be a consequence of functional, structural, or evolutionary relationships between the sequences. Aligned sequences of nucleotide or amino acid residues are typically represented as rows within a matrix. Gaps are inserted between the residues so that identical or similar characters are aligned in successive columns.

Alkaloid(s): Alkaloids are a group of naturally occurring chemical compounds, that contain mostly basic nitrogen atoms. This group also includes some related compounds with neutral and even weakly acidic properties. Some synthetic compounds of similar structure are also attributed to alkaloids. In addition to carbon, hydrogen and nitrogen, alkaloids may also contain oxygen, sulfur and more rarely other elements

such as chlorine, bromine, and phosphorus. Alkaloids are produced by a large variety of organisms, including bacteria, fungi, plants, and animals, and are part of the group of natural products (also called secondary metabolites). Many alkaloids can be purified from crude extracts by acid-base extraction. Many alkaloids are toxic to other organisms. They often have pharmacological effects and are used as medications, as recreational drugs, or in entheogenic rituals. Examples are the local anesthetic and stimulant cocaine; the psychedelic psilocin; the stimulant caffeine; nicotine; the analgesic morphine; the antibacterial berberine; the anticancer compound vincristine; the antihypertension agent reserpine; the cholinomimeric galantamine; the spasmolysis agent atropine; the vasodilator vincamine; the anti-arhythmia compound quinidine; the anti-asthma therapeutic ephedrine; and the antimalarial drug quinine. Although alkaloids act on a diversity of metabolic systems in humans and other animals, they almost uniformly invoke a bitter taste.

Allantoid: 1. (Reference to spores) Curved as in sausage shape. 2. Spores with adaxial side concave and parallel to abaxial side.

Allele(s): Any one of two or more alternative forms of a gene that may occur alternatively at a given site on a chromosome. Alleles may occur in pairs, or there may be multiple alleles affecting the expression of a particular trait. If paired alleles are the same, the organism is said to be homozygous for that trait; if they are different, the organism is heterozygous. A dominant allele will override the traits of a recessive allele in a heterozygous pairing (see dominance and recessiveness). In some traits, alleles may be codominant (i.e., neither acts as dominant or recessive). An individual cannot possess more than two alleles for a given trait. All genetic traits are the result of the interactions of alleles.

Allocyst (Allocysts): 1. Mycelium cystidia-like cells resembling cheilocystidia from the true gill edges. 2. Hyphae with terminal swelling.

Allopatric Speciation: Speciation that depends on an external barrier to gene flow (such as geographic isolation) to begin or complete the process of speciation.

Allopatry: Occurring in separate, non-overlapping geographic areas. This term is usually used to describe populations of related organisms unable to cross breed because of geographic separation.

Alternating Phosphate and Sugar Residues: The backbone of a DNA strand with the nucleobases (G, A, T, C) attached to the sugars.

Amanitaceae: Amanitaceae are a family of fungi or mushrooms. The family, also commonly called the Amanita family, is in the order *Agaricales*. The family consists primarily of the genus Amanita, but also includes the genera Catatrama and Limacella. Mycological works show great divergence in their definitions of families and the up-to-date and authoritative Index fungorum classifies these fungi as part of Pluteaceae. For a long time, they were placed in Agaricaceae. The species are usually found in woodlands. They emerge from an egg-like structure formed by the universal veil. This family contains several species that are valued for edibility and flavor and others that are deadly poison. More than half the cases of mushroom poisoning stem from members of this family. The most toxic members of this group have names that warn of the poisonous nature, but others, of varying degrees of toxicity, do not.

Amatoxins: Amatoxins are a subgroup of at least eight toxic compounds found in several genera of

poisonous mushrooms, most notably Amanita phalloides and several other members of the genus Amanita, as well as some Conocybe, Galerina and Lepiota mushroom species.

Amorphous: Of no particular kind or character; indeterminate; having no pattern or structure; unorganized.

Amphicoelous: Biconcave. Concave on both sides.

Amphimitic: 1. Composed of generative and binding hyphae. 2. Trama composed of generative and ligative (bindung) hyphae (i.e. thick-walled, often without lumen, distinctly branched and winding around the other hyphae.) This includes tramal structures that contain elements which are ligative only at their distal ends but appearing to be normal skeletals in their lower portion and also the hyphal systems in which skeletals often but not regularly pass into ligative hyphae.

Ampullate: Flask-shaped.

Ampulliform: Flask-shaped. Dilated.

Amygdaliform: (Reference to spores) Almond shaped.

Amyloid: The term amyloid refers to a chemical test using iodine in either Melzer's reagent or Lugol's solution, to produce a black to blue-black positive reaction. It is called amyloid because starch gives a similar reaction, and that reaction for starch is also called an amyloid reaction. The test can either be on microscopic features, such as spore walls or hyphal walls, or the apical apparatus on an ascus, or be a macroscopic reaction on tissue where a drop of the reagent is applied. Negative reactions, called inamyloid or nonamyloid reactions are for structures that remain pale brown or clear. A deep reddish to reddish brown reaction is termed either a pseudoamyloid reaction or a dextrinoid reaction.

Anamorph (Anamorphs, Anamorphic): An asexual reproductive stage of a fungi.

Anastomosing Gills: Lamellae provided with irregular transverse connections. Fused together in a vein-like network. A term for mushroom gills that are interconnected with vein-like tissue formations.

Above: A possible siting of *Mycena galericulata* and its anastomosing gills courtesy Alan Rockefeller

Anastomosis (Anastomose, Anastomoses): In mycology, anastomosis is the fusion between branches of the same or different hyphae. Hence the bifurcating fungal hyphae can form true reticulating networks. By sharing materials in the form of dissolved ions, hormones, and nucleotides, the fungus maintains bidirectional communication with itself. The fungal network might begin from several origins; several spores (i.e. by means of conidial anastomosis tubes), several points of penetration, each a spreading circumference of absorption and assimilation. Once encountering the tip of another expanding, exploring self, the tips press against each other in pheromonal recognition or by an unknown recognition system, fusing to form a genetic singular that can cover hectares called a genet or just microscopical areas. For fungi, anastomosis is also a component of sex. In some fungi, two different haploid mating types - if compatible - merge. Somatically, they form a morphologically similar mycelial wave front that continues to grow and explore. The significant difference, is that in each septated unit is binucleate, containing two unfused nuclei, i.e. one from each parent that will eventually undergo karyogamy and meiosis to complete the sexual cycle.

Angiocarpous: A mushroom specimen that is closed (at the cap) at least until the spores are mature.

Angiocarpy: A type of development of the basidiocarp in which at some stage the developing hymenium is situated in a closed cavity. See also primary and secondary angiocarpy.

Angular: Having, forming, or consisting of an angle or angles.

Annuliform Zone: Annular zone. Annulus ring. The zone where the annulus or ring forms.

Anthropological Studies: Anthropology is the study of humankind, past and present, that draws and builds upon knowledge from social and biological sciences, as well as the humanities and the natural sciences. In mycology, anthropological studies can be important in determining the uses (cultural, medicinal, culinary, etc) of a fungi and the role of a fungi in a society. See "ethnomycology".

Aperture: A hole or an opening through which light travels. This opening can be widened or narrowed to desired setting. If an aperture is narrow, then highly collimated rays are admitted, resulting in a sharp focus at the image plane. If an aperture is wide, then uncollimated rays are admitted, resulting in a sharp focus only for rays with a certain focal length.

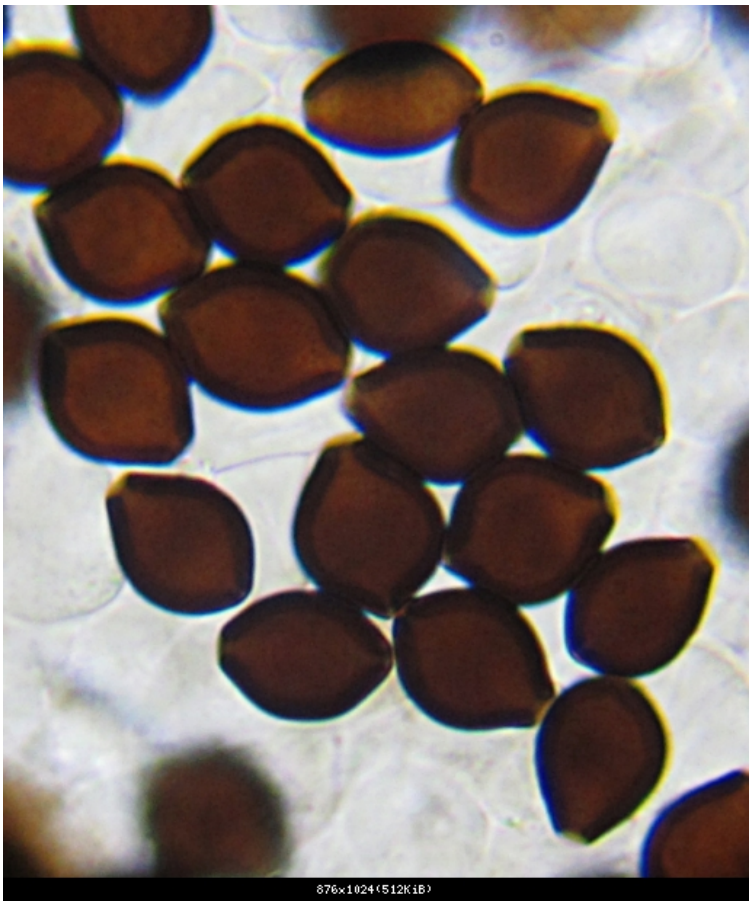
Apex: The highest point of an item. The tip. The summit. In spores the apex is the same as the Distal End.

Apical: From the Latin *apex*; meaning to be at the apex or tip. Situated at the tip.

Apical Annulus (Synonymous with Superior Annulus): Annulus located at or near the top of the stipe.

Apical Germ Pore (Synonymous with Germ Pore and Apical Pore): "Apical germ pore" is a term applied to mushroom spores which have a pore (hole) at one end.

Below: Apical germ pore (*Panaeolus acuminatus*) courtesy of Byrain



Apical Projections: Horns. This term has been used to describe the tip protuberances emanating from cystidia in *Pluteus cervinus*.

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Above: Cystidia apical projections are observed in *Pluteus cervinus* by zzz

Apices With Protuberances: In cystidia that have protuberant apices, the extension may be in the shape of a ball, a beak, or a sharp point.

Apiculus: (Reference to spores) A short projection at the base. Synonymous with the Hilar Appendage.

Appendages: More than one protuberance in which case the extensions are called appendages. Oftentimes these cystidia are called forked or furcate. Most of the time the term "appendage" is used to refer to the *hilar appendage* on a spore.

Applanate (Applanation): Flattened. Flat. Undue flatness. Used usually when referring to the suprahilar disc or plage.

Appressoria: An appressorium is a specialized cell typical of many fungal plant pathogens that is used to infect host plants. It is a flattened, hyphal "pressing" organ, from which a minute infection peg grows and enters the host, using turgor pressure capable of punching through even Mylar. Following spore attachment and germination on the host surface, the emerging germ tube perceives physical cues such as surface hardness and hydrophobicity, as well as chemical signals including wax monomers that trigger appressorium formation. Appressorium formation begins when the tip of the germ tube ceases polar growth, hooks, and begins to swell. The contents of the spore are then mobilized into the developing appressorium, a septum develops at the neck of the appressorium, and the germ tube and spore collapse and die. As the appressorium matures, it becomes firmly attached to the plant surface and a dense layer of melanin is laid down in the appressorium wall, except across a pore at the plant interface. Turgor pressure increases inside the appressorium and a penetration hyphae emerges at the pore, which is driven through the plant cuticle into the underlying epidermal cells.

Agaricoid: A fungi species capable of producing mushroom specimens.

Arcuate: Lamellae with concave lamella edge.

Areolate: Surface cracked into plaques or blocks, like the cracking that occurs when mud dries in the sun.

Areolate-Rimose: Rimose-areolate will refer to deep and dramatic cracks in a surface (say, more than 2 mm wide and deep).

Arthroconidium (Pl., Arthroconidia): 1. Arthroconidia are a type of fungal spores that typically are produced by segmentation of pre-existing fungal hyphae. 2. An asexual spore which is the product of separation and fragmentation of true fungal hyphae. 3. A conidium released by fragmentation or separation at the septum of cells of the hypha.

Aseptate: Without septa. Excretory hyphae in Pholiota and Stropharia mushrooms.

Asperulate: Delicately roughened.

Assay: An assay is an investigative (analytic) procedure in laboratory medicine, pharmacology, environmental biology, and molecular biology for qualitatively assessing or quantitatively measuring the presence or amount or the functional activity of a target entity (the analyte) which can be a drug or biochemical substance or a cell in an organism or organic sample. The measured entity is generally called the analyte, or the measurand or the target of the assay. The assay usually aims to measure an intensive property of the analyte and express it in the relevant measurement unit (e.g. molarity, density, functional activity in enzyme international units, degree of some effect in comparison to a standard, etc).

Assisted Migration: Assisted colonization, also known as assisted migration or managed relocation, refers to the act of deliberately helping plant and animal species colonize new habitats when driven out of their historical habitats due to rapid environmental change, especially climate change. All species have some natural capacity to disperse into new habitats and adapt to change, but ongoing climate change is occurring so rapidly that many species are unable to keep pace naturally. In order to prevent extinctions, some scientists and practitioners are considering assisting the dispersal of species that have poor natural dispersal ability. This idea has sparked intense debate over the potential benefits of performing assisted colonization, which include avoiding many species extinctions, and the risks, which include accidentally introducing new invasive species. Although the debate remains primarily conceptual with few real-world applications, scientists and land managers have already begun to consider several specific assisted colonization projects.

Asteriform: Star-shaped.

Asterocystidia: Thin-walled, acuminate hymenocystidia with apical, stellate mass of large crystals (Resinicium).

Asterophysis (Astrosetae): A thick-walled cystidium which is star-shaped at the apex and swollen below.

Asterostromelloid: Describes tissue which is made of branched hyphae where many branches start at right angles along the main axis, giving the ends a star like appearance.

Astrocystidia: Cystidia with an apical star-like cluster of pointed hyaline crystals.

Asymmetrical: Having no balance or symmetry. Uneven, odd, unbalanced, lopsided, not parallel. One side does not equally match the other side (usually used in reference to certain spore shapes).

Attached Annulus: Annulus connected to the stipe at maturity and unremovable.

Au Naturale: This is a loosely used term to simply tell viewers that the microscopy image was taken of a specimen that had no staining agent, no cover slip, and no mounting agent. It is naked and all natural.

Auct.: Synonymous with author(s) or auctores.

Auct. eur.: European authors.

Auct. Non.: The use of "auct. non" denotes a common misapplication or misinterpretation of a species

name, i.e., a taxon that was identified erroneously as the named species, but not in the sense of the original author. When the identification of a plant is misapplied, rather than based on the original author's description, the name is placed in synonymy with the correct species name, and the abbreviation "auct. non" is placed before the original author's name.

Av.: Abbreviation for "average."

Avellaneous: Hazel color (light brown to strong yellowish brown).

avl: Average length.

avQ: Average quotient. Not the same as "Q" which is the quotient of length and width.

avw: Average width.

Bacciform: Shaped like a berry.

Bacilliform (Bacciliform): 1. Like a bacillus; rod-shaped. 2. Spore Q>3.0

Baeocystin: Baeocystin is a psilocybin mushroom alkaloid and analog of psilocybin. It is found as a minor compound in most psilocybin mushrooms together with psilocybin, norbaeocystin, and psilocin. Baeocystin is a N-demethylated derivative of Psilocybin, and a phosphorylated derivative of 4-HO-NMT (4-hydroxy-N-methyltryptamine). Baeocystin was first isolated from the mushroom *Psilocybe baeocystis*, and later from *P. semilanceata*. It was first synthesized by Troxler et al. (1959).

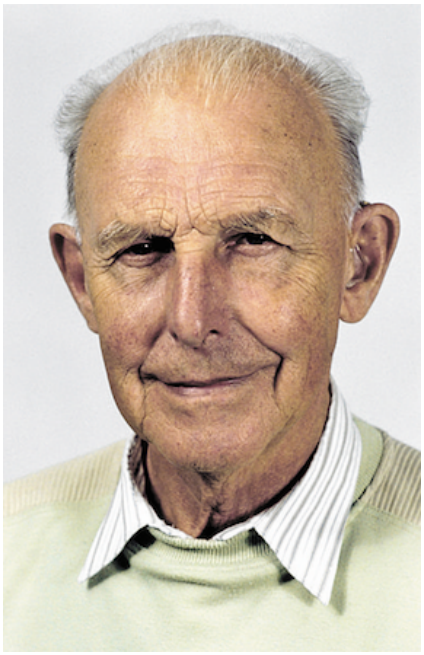
Bald: The surface of a part (usually the pileus surface) showing no warts or hairs, nor raised scales, nor fibers, nor patches. Synonymous with the term "glabrous" and "naked".

Balistosporic Basidium: Basidium that actively ejects/discharges spores.

Ballistospores: A ballistospore or ballistoconida is a spore that is discharged into the air from a species of fungus. A ballistospore or ballistoconida is a spore that is discharged into the air from a living being, usually a species of fungus. With fungi, most types of basidiospores formed on basidia are discharged into the air from the tips of sterigmata. At least 30 thousand species of mushrooms, basidiomycete yeasts, and other fungal groups may discharge ballistospores, sometimes at initial accelerations exceeding 10 thousand times *g*.

Barbellate: Having short, stiff, hooked bristles. Finely or minutely barbed.

Bas: Described by Dr. Cornelis Bas



Above: Dr. Bas courtesy Wikimedia Commons and Persoonia

Basal Annulus (Synonymous with Inferior Annulus): Annulus located on the lower to bottom portion of the stipe.

Basal Bulb: A roundish, Christmas bulb-like shape at the base of the stipe.

Basal Clamp (Basal Clamps, Basal Clamp Connections): A clamp connection at the base of a cell, used often in describing basidia and some cystidia if present.

Basal Cup: The cup-like structure (layer) at the base of the stipe on some mushroom species (Amanita in particular). Also known as the volva.

Basal Grade (Basal Position): Forming or belonging to the bottom layer or base of a phylogenetic tree.

Basal Mycelium: Mycelium connected to the base of the stipe.

Basal Parts: Portion of a structure which forms its base.

Basal Stipe Disc (Basal Disc): A circular outgrowth at the base of stipe as seen in *Mycena adscendens*.

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Above: A basal disc is traditionally seen in the species zzz. Image courtesy zzz.

Base (Synonymous with Proximal End): For spores, the base is always defined by the area where the spore connected to the sterigma of the basidium (ie the hilar appendage). (The apex would be the top of the spore; the opposite end of the hilar appendage).

Base Pairs: Base pairs are the building blocks of the DNA double helix, and contribute to the folded structure of both DNA and RNA. Dictated by specific hydrogen bonding patterns, Watson-Crick base pairs

(guanine-cytosine and adenine-thymine) allow the DNA helix to maintain a regular helical structure that is independent of its nucleotide sequence.

Basidiocarp: 1. The fruiting body produced by a mycelium (i.e. a gilled mushroom). 2. In fungi, a basidiocarp, basidiome or basidioma (plural: basidiomata), is the sporocarp of a basidiomycete, the multicellular structure on which the spore-producing hymenium is borne. Basidiocarps are characteristic of the hymenomycetes; rusts and smuts do not produce such structures. As with other sporocarps, epigeous (above-ground) basidiocarps that are visible to the naked eye (especially those with a more or less agaricoid morphology) are commonly referred to as mushrooms, while hypogeous (underground) basidiocarps are usually called false truffles.

Basidiole (pl. basidioles): Basidioles are still not definitively understood and are therefore worth studying casually. They are believed to be immature basidia by some. It seems worthwhile to consider that some basidioles are immature basidium while others are providing a different function. Basidioles may be mistaken for a clavate cystidia due to lack of sterigmata.

Basidioma (Pl., Basidiomata): In fungi, a basidiocarp, basidiome or basidioma (plural: basidiomata), is the sporocarp of a basidiomycete, the multicellular structure on which the spore-producing hymenium is borne. Basidiocarps are characteristic of the hymenomycetes; rusts and smuts do not produce such structures.

Basidiome (Pl., Basidiomes): A basidiocarp. A mushroom which has basidia. Fruitbody or carpophore.

Basidiomycetes: Major group of fungi characterised by development of basidia on which sexual basidiaspores are produced. Includes gill bearing fungi, boletes, polypores, clavarias, jelly fungi, & gasteromycetes.

Basidiomycota: One of two large phyla that, together with the Ascomycota, comprise the subkingdom Dikarya (often referred to as the "higher fungi") within the kingdom Fungi. More specifically the Basidiomycota include these groups: Mushrooms, puffballs, stinkhorns, bracket fungi, other polypores, jelly fungi, boletes, chanterelles, earth stars, smuts, bunts, rusts, mirror yeasts, and the human pathogenic yeast Cryptococcus. Basically, Basidiomycota are filamentous fungi composed of hyphae (except for yeasts), and reproducing sexually via the formation of specialized club-shaped end cells called basidia that normally bear external meiospores (usually four). These specialized spores are called basidiospores. However, some Basidiomycota reproduce asexually in addition or exclusively. Basidiomycota that reproduce asexually can be recognized as members of this phylum by gross similarity to others, by the formation of a distinctive anatomical feature (the clamp connection), cell wall components, and definitively by phylogenetic molecular analysis of DNA sequence data.

Basidiospores: Spores that come from basidia versus asci (or conidiophores).

Basidium (pl., basidia): is a microscopic, spore-producing structure found on the hymenophore of fruiting bodies of basidiomycete fungi. The presence of basidia is one of the main characteristic features of the Basidiomycota. A basidium usually bears four sexual spores called basidiospores; occasionally the number may be two or even eight. In a typical basidium, each basidiospore is borne at the tip of a narrow prong or horn called a sterigma (pl. sterigmata), and is forcibly discharged upon maturity.

Basionym (Basionyms): Basionym, in the scientific name of organisms, means the 'original name' on which a new name is based. The term is primarily used in botanical nomenclature, the scientific naming of plants. Use of the term "basionym" is regulated by the International Code of Nomenclature for algae, fungi, and plants, where it is defined as: The legitimate, previously published name on which a new combination or name at new rank is based. (Art. 6.10)

Beta Glucan (Synonymous with Beta Glycan): ß-Glucans are polysaccharides that contain only glucose as structural components, and are linked with ß-glycosidic bonds. ß-Glucans are known as "biological response modifiers" because of their ability to activate the immune system. ß-Glucans (beta-glucans) are polysaccharides of D-glucose monomers linked by ß-glycosidic bonds.

Beta-Tubulin Gene: Area of DNA analyzed in phylogenetic and evolutionary studies.

Biacapiculate: More or less lemon-shaped.

Biconvex: Convex on both sides or surfaces. A biconvex disk (a biconvex spore).

Bifid: Bifid refers to something that is split or cleft into two parts. Forked. Usually refers to forked cheilocystidia.

Bifurcate (Bifurcation): To divide into two branches or parts - for example forked cheilocystidia.

Bilateral (Synonymous with Divergent): Hymenophoral trama having downward hyphae turning outward from a median line.

Bilateral Gill Trama: A type of gill trama that has a central strand of hyphae, from which other strands of hyphae diverge at slanted angles.

Bilaterally Symmetrical Spore: The characteristic of being symmetric about a plane running from apex to base.

Binding Hyphae (Synonymous with Ligative Hyphae): 1. Branching, rarely septate, thick-walled, narrow hyphae binding the other elements of a tissue together. 2. Thick-walled, distinctly branched, tortuous, often lacking a lumen.

Binomial: Combination of two names/words, usually joined by a hyphen. Sometimes seen with species names.

Binucleate: With two nuclei.

Bioassay: Bioassay (commonly used shorthand for biological assay), or biological standardization is a type of scientific experiment. Bioassays are typically conducted to measure the effects of a substance on a living organism and are essential in the development of new drugs and in monitoring environmental pollutants. Both are procedures by which the potency or the nature of a substance is estimated by studying its effects on living matter. Bioassay is a procedure for the determination of the concentration of

a particular constitution of a mixture.

Biofilm: A biofilm is any group of microorganisms in which cells stick to each other on a surface. These adherent cells are frequently embedded within a self-produced matrix of extracellular polymeric substance (EPS). Biofilm extracellular polymeric substance, which is also referred to as slime (although not everything described as slime is a biofilm), is a polymeric conglomeration generally composed of extracellular DNA, proteins, and polysaccharides. Biofilms may form on living or non-living surfaces and can be prevalent in natural, industrial and hospital settings. The microbial cells growing in a biofilm are physiologically distinct from planktonic cells of the same organism, which, by contrast, are single-cells that may float or swim in a liquid medium. Microbes form a biofilm in response to many factors, which may include cellular recognition of specific or non-specific attachment sites on a surface, nutritional cues, or in some cases, by exposure of planktonic cells to sub-inhibitory concentrations of antibiotics. When a cell switches to the biofilm mode of growth, it undergoes a phenotypic shift in behavior in which large suites of genes are differentially regulated.

Biological Species Concept: The biological species concept defines a species as members of populations that actually or potentially interbreed in nature, not according to similarity of appearance. Although appearance is helpful in identifying species, it does not define species.

Biological Systematics: Biological systematics is the study of the diversification of living forms, both past and present, and the relationships among living things through time. Relationships are visualized as evolutionary trees (synonyms: cladograms, phylogenetic trees, phylogenies). Phylogenies have two components, branching order (showing group relationships) and branch length (showing amount of evolution). Phylogenetic trees of species and higher taxa are used to study the evolution of traits (e.g., anatomical or molecular characteristics) and the distribution of organisms (biogeography). Systematics, in other words, is used to understand the evolutionary history of life on Earth.
"Systematic biology" and "taxonomy" (terms that are often confused and used interchangeably) were defined in relationship to one another as follows: Systematic biology (hereafter called simply systematics) is the field that (a) provides scientific names for organisms, (b) describes them, (c) preserves collections of them, (d) provides classifications for the organisms, keys for their identification, and data on their distributions, (e) investigates their evolutionary histories, and (f) considers their environmental adaptations. This is a field with a long history that in recent years has experienced a notable renaissance, principally with respect to theoretical content. Part of the theoretical material has to do with evolutionary areas (topics e and f above), the rest relates especially to the problem of classification. Taxonomy is that part of Systematics concerned with topics (a) to (d) above.

Bioluminescent (BIOLUMINESCENCE): The production of light by living organisms is referred to as "bioluminescence." It is an example of an endergonic reaction driven by ATP hydrolysis that involves a conversion of energy forms (a chemical that causes light). The chemical that becomes luminescent is called luciferin (after the light-bearing fallen angel). This reaction and the enzyme that catalyzes it (luciferase) occur in a wide variety of organisms including the firefly. This includes a variety of marine organisms, microorganisms, worms, and mushrooms. The light is generally used to avoid predators or for signaling to mates. Soft-drink companies use the firefly proteins luciferin and luciferase to detect bacterial contamination. Where there are living cells there is ATP, and when the firefly proteins encounter ATP and oxygen, they give off light. Thus, a sample of soda that lights up in the test is contaminated with bacteria and is discarded.

Biosphere: The biosphere is the global sum of all ecosystems. It can also be called the zone of life on Earth, a closed (apart from solar and cosmic radiation) and self-regulating system. From the broadest biophysiological point of view, the biosphere is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere, hydrosphere and atmosphere. The biosphere is postulated to have evolved, beginning through a process of biogenesis or biopoesis, at least some 3.5 billion years ago.

Biota: Biota are the total collection of organisms of a geographic region or a time period, from local geographic scales and instantaneous temporal scales all the way up to whole-planet and whole-timescale spatiotemporal scales. The biota, or biotic component of the Earth make up the biosphere.

Biotic Components: 'Biotic components' are the living things that shape an ecosystem. A 'biotic factor' is any living component that affects another organism, including animals that consume the organism in question, and the living food that the organism consumes. Each biotic factor neto abiotic components, which are non-living components of an organism's environment, such as temperature, light, moisture, air currents, etc. Biotic components usually include:
1. Producers, i.e. autotrophs: e.g. plants, they convert the energy [from photosynthesis (the transfer of sunlight, water, and carbon dioxide into energy), or other sources such as hydrothermal vents] into food.
2. Consumers, i.e. heterotrophs: e.g. animals, they depend upon producers (occasionally other consumers) for food.
3. Decomposers, i.e. detritivores: e.g. fungi and bacteria, they break down chemicals from producers and consumers (usually dead) into simpler form which can be reused.

Biscoctiform: Biscuit-shaped.

Bivelangiocarpous (Bivelangiocarpic): Hymenium covered by two veils during development of the sporocarp. Having both an inner partial veil and an enveloping universal veil.

BLAST: Basic Local Alignment Search Tool, or BLAST, is an algorithm for comparing primary biological sequence information, such as the amino-acid sequences of different proteins or the nucleotides of DNA sequences. A BLAST search enables a researcher to compare a query sequence with a library or database of sequences, and identify library sequences that resemble the query sequence above a certain threshold. Different types of BLASTs are available according to the query sequences. For example, following the discovery of a previously unknown gene in the mouse, a scientist will typically perform a BLAST search of the human genome to see if humans carry a similar gene; BLAST will identify sequences in the human genome that resemble the mouse gene based on similarity of sequence.

Bluing Reaction: A color-changing action in certain species (and collections) of psilocybin/psilocin-containing mushrooms in which, after being touched, a blue colorization change occurs over the course of seconds or minutes. In some collections of psilocybin mushrooms failing to show the bluing reaction initially, a sample of the collection can sometimes be placed in a sealed tupperware container (with holes on the top for limited air exchange). The container is placed in the fridge for a few hours which can help induce a bluing reaction. Note: The bluing reaction is not directly synonymous with a collection found with bluing already on it before handling.

Brachybasidiole (pl., brachybasidioles): Cells which resemble a basidiole but are larger and more inflated. For a visual look at
Bolbitius titubans microscopically.

Brachycystidia: A type of leptocystidia - cells shaped like a stone walkway more or less. Found in Coprinus species.

Branched Gills (Branching Gills): Primary gills which branch out (or fork out) forming either secondary, tertiary, or quaternary gills from the primary gill(s).

Branching: New hyphae are typically formed by emergence of new tips along existing hyphae by a process called branching.

Breadth of a Spore: Largest distance between sides as seen from frontal view.

Broadly Clavate: Club-shaped cystidia with Q less than 1.5.

Broadly Cylindrical: Cystidia that are cylindrical with a Q<2.

Broadly Ellipsoid: Spore Q=1.15-1.30. Cystidia Q=1.15-1.30.

Broom Cells: Unusual cells found on the cap surfaces of some mushrooms, (for example in the genus Marasmius), where their presence or absence, together with their shapes and dimensions, can help in the identification process. They can have a vague resemblance to basidia in terms of shape. The have strong resemblance to a literal broom.

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Above: Broom cells emerging from the pileus surface

Bryophyte: Bryophyte is a traditional name used to refer to all embryophytes (land plants) that do not have true vascular tissue and are therefore called 'non-vascular plants'. Some bryophytes do have specialized tissues for the transport of water; however since these do not contain lignin, they are not considered to be true vascular tissue. Bryophytes are thought not to be a natural or monophyletic group; however the name is convenient and remains in use as a collective term for mosses, hornworts, and liverworts by some while others separate hornworts and liverworts into their own categories. Bryophytes produce enclosed reproductive structures (gametangia and sporangia), but they produce neither flowers nor seeds, reproducing via spores. The term bryophyte comes from Greek βρύον - bryon, "tree-moss, oyster-green" + φυτόν - fyton "plant".

Bolbitiaceae: The Bolbitiaceae are a family of basidiomycete fungi. There are 17 genera and 171 species in the family.

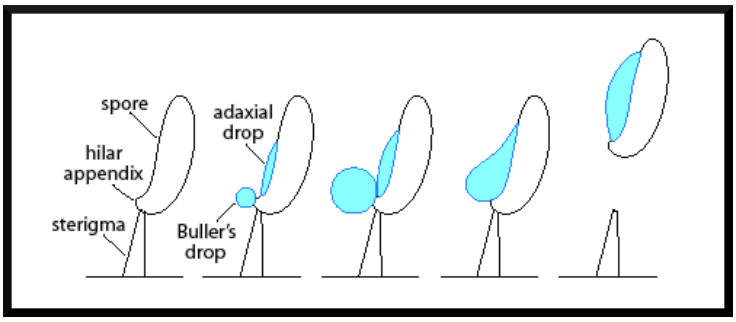
Bulbipellis: Skin surface of the stipe bulb.

Bulbus: A bulb-shaped anatomical structure at the base of the stipe (found in some species of mushroom-fruiting fungi).

Buller: The standard author abbreviation Buller is used to indicate Arthur Henry Reginald Buller as the author when citing a mycological name.

Above: Dr. Buller (August 19, 1874 – July 3, 1944) courtesy Buller Memorial Library in Canada

Buller's drop: A drop of water that grows on a spore's hilar appendage and plays a role in the ejection process of the spore.



Above: Buller's drop. A drop of water that grows on a spore's hilar appendage and plays a role in the ejection process of the spore.

Bullet-Shaped: Shaped like a bullet. See spores of Lepiota castanea.

Bulliform: Bubble-shaped and swollen.

Bursiform: Bag-like.

ca.: An abbreviation for the Latin word "Circa," which means "about."

ca. 1.5 kb: Specific area from a region of genomic DNA taken from the LSU (Large SubUnit) nuclear ribosomal RNA gene cluster.

Caespitose: Fungi growing closely to one another but not directly attached (ie at the base or otherwise).

Calcium Oxalate Crystals: A chemical compound that forms envelope-shaped crystals, known in plants as raphides. A major constituent of human kidney stones, the chemical is also found in beerstone, a scale that forms on containers used in breweries. Its chemical formula is CaC_2O_4 or $Ca(COO)_2$.

Callus (Apical Callus): Common in Galerina (when viewed in KOH) spore germ pore.

Calyptrate: Having a calyptra. The protective cap or hood covering some spore types.

Campanulate: Bell-shaped.

Cantharellaceae: The Cantharellaceae are a family of fungi in the order Cantharellales. The family contains the chanterelles and related species, a group of fungi that superficially resemble agarics (gilled mushrooms) but have smooth, wrinkled, or gill-like hymenophores (spore-bearing undersurfaces). Species in the family are ectomycorrhizal, forming a mutually beneficial relationship with the roots of trees and other plants. Many of the Cantharellaceae, including the chanterelle (Cantharellus cibarius), the Pacific golden chanterelle (Cantharellus formosus), the horn of plenty (Craterellus cornucopioides), and the trumpet chanterelle (Craterellus tubaeformis), are not only edible, but are collected and marketed internationally on a commercial scale.

Capitate: Enlarged and swollen at the tip. Knob-like form at the apex of a cystidium.

Capitulate: Cystidia which are basically filiform or cylindrical except for the apex which is swollen into a small knob or head.

Caput: Having ball or head-like protuberances.

Carbohydrate (Sometimes Synonymous with Saccharide or Simple Sugar): 1. Carbohydrates are the most abundant class of organic compounds found in living organisms and provide metabolic energy. 2. Carbohydrates are a large group of organic compounds, including sugars, such as sucrose, and polysaccharides, such as cellulose, glycogen, and starch, that contain carbon, hydrogen, and oxygen.

Carminophilous: Reaction with acetocarmine. Becoming dark-dotted in a solution of acerocarmine; used in reference to microscopic basidia.

Carpophore (Pl. Carpophores): The fruiting body of the higher fungi.

Catahymenium: Basidium not arranged in a single layer.

Caulocystidioid Hairs (Caulocystidioid Hairs): Cystidioid terminal cells of superficial hyphae on stipe, paracystidia not present among these cells, can resemble metuloids.

Caulocystidium (pl., Caulocystidia): Cystidia located on the stipe. Abbreviated "cc".

Caulogloeocystidium (Pl., Caulogloeocystidia): Cystidia on the stipe (caulocystidia) which have oily or granular contents.

Cauloparacystidia: Cells on the stipe similar to paracystidia found on gill edge.

Cell (See Fungal Cell Below): The cell is the basic structural and functional unit of all known living organisms. It is the smallest unit of life that is classified as a living thing, and is often called the building block of life. Organisms can be classified as unicellular (consisting of a single cell; including most bacteria) or multicellular (including plants and animals). Humans contain about 10 trillion cells. Most plant and animal cells are between 1 and 100 µm and therefore are visible only under the microscope. The cell was discovered by Robert Hooke in 1665. In 1835, before the final cell theory was developed, Jan Evangelista Purkyně observed small "granules" while looking at the plant tissue through a microscope. The cell theory, first developed in 1839 by Matthias Jakob Schleiden and Theodor Schwann, states that all organisms are composed of one or more cells, that all cells come from preexisting cells, that vital functions of an organism occur within cells, and that all cells contain the hereditary information necessary for regulating cell functions and for transmitting information to the next generation of cells. The word cell comes from the Latin cella, meaning "small room". The descriptive term for the smallest living biological structure was coined by Robert Hooke in a book he published in 1665 when he compared the cork cells he saw through his microscope to the small rooms monks lived in.

Cell Biology: Cell biology (formerly "cytology") is a scientific discipline that studies cells – their physiological properties, their structure, the organelles they contain, interactions with their environment, their life cycle, division and death. This is done both on a microscopic and molecular level. Cell biology research encompasses both the great diversity of single-celled organisms like bacteria and protozoa, as well as the many specialized cells in multicellular organisms such as humans. Knowing the components of cells and how cells work is fundamental to all biological sciences.

Cellular Elements: (**xyz**) A general term to describe microscopic structures that are cellular (globose, subglobose, ellipsoid or polyhedral) in form. Term used sometimes with cystidioid elements. Composed of rounded cells, not thread-like ones.

Cellular Hyphae: Inflated and packed together to resemble plant parenchyma.

Cellular Mediopellis: If the pellis of a fungus has three distinct layers the outer layer is the suprapellis, the middle layer is the mediopellis and the inner layer is the subpellis, below that is the pileus trama, the term "cellular mediopellis" describes that the elements that make up the mediopellis are cellular.

Cellular Pileipellis (Cellular Cuticle): A cystoderm is also known as a cellular cuticle. Applied to pellis consisting of rounded elements; same as polycystoderm.

Cellular Subhymenium: 1. The subhymenium is the layer of elements connecting the basidia, cystidia and

other cells like basidioles with the hymenophoral trama, all of these structures can be viewed in a tangential section that shows a cross section of the gills, elements of a cellular subhymenium are ellipsoid to more or less isodiametric (spherical or polyhedral) in shape. 2. A type of subhymenia in which the cells are ellipsoid to isodiametric.

Cellular Subpellis: If the pileipellis of a fungus has more than one layer the layer that is next to the pileus trama is known as the subpellis, a "cellular subpellis" consists of cellular elements.

Cellulose: Cellulose is an organic compound with the formula $(C_6H_{10}O_5)_n$, a polysaccharide consisting of a linear chain of several hundred to over ten thousand $\beta(1\rightarrow4)$ linked D-glucose units.

Cell Wall: The cell wall is the tough, usually flexible but sometimes fairly rigid layer that surrounds some types of cells. It is located outside the cell membrane and provides these cells with structural support and protection, in addition to acting as a filtering mechanism. A major function of the cell wall is to act as a pressure vessel, preventing over-expansion when water enters the cell. Cell walls are found in plants, bacteria, fungi, algae, and some archaea. Animals and protozoa do not have cell walls. Fungi possess cell walls made of the glucosamine polymer chitin, and algae typically possess walls made of glycoproteins and polysaccharides.

Centered Germ Pore: The germ pore is not offset with the hilar appendage area. The germ pore is in the center of the apex of the spore.

Central: Germ pore situated at the central tip of the spore.

Centromere: The point where two chromatids touch (and where the microtubules attach). The centromere is the part of a chromosome that links sister chromatids.

Cespitose: Growing in dense clusters, with the stems fused together or packed right up against one another at the base.

Cf. (cf.): Means 'refer to' or 'compare to.' The abbreviation is most often seen in English writing. It may be used, for example, to invite readers to compare an author's discussion with that presented in another work.

Chambered (Chambers): The stipe has hollow sections (chambers) as opposed to being hollow throughout.

Cheilocatenulae: Multicellular hyphae with differentiated elements which often disarticulate. The form "cystidia" on the gill edge of some mushrooms. 2. Multicellular hyphae which project into the hymenium of the gill edge, the elements of which are in chains (catenulate) and inflated.

Cheilocystidium (pl., cheilocystidia) (Pronounced Kye-Low-Sis-tid-ium): A cystidium (plural cystidia) is a relatively large cell found on the hymenium of a basidiomycete (for example, on the surface of a mushroom gill), often between clusters of basidia. Since cystidia have highly varied and distinct shapes that are often unique to a particular species or genus, they are a useful in the identification of basidiomycetes. In general, the adaptive significance of cystidia is not well understood. Cheilocystidia are

located on the true gill edges. In general, cheilocystidia tend to vary in morphology more than pleurocystidia, but they are typically reasonably constant for a species and in many instances do furnish valuable taxonomic characters. The size varies with the species being small in some (14-20 µ long) and up to 75µ long in others. By definition cheilocystidia are the hyphal end-cells on the gill edge which do not produce basidiospores. They may be in the form of basidioles, resemble the pleurocystidia in shape, or have their own distinctive morphological characters. Abbreviated "ch".

Cheilopseudocystidium (pl., cheilopseudocystidia): Pseudocystidium located on the true gill edge.

Chemotaxonomic (Chemotaxonomy, Chemosystematics): Chemotaxonomy (from chemistry and taxonomy), also called chemosystematics, is the attempt to classify and identify organisms (originally plants), according to demonstrable differences and similarities in their biochemical compositions. The compounds studied in most of the cases are mostly proteins, amino acids and peptides. Examples of chemotaxonomic markers are phospholipid-derived fatty acids and enzymes.

Cherocytes: 1. Loose, globose cells with long excrescences or spines located on the pileipellis, stipe surface, and/or the universal veil of some bioluminescent species *(Amparoina spinosissima, Mycena asterina)*. 2. Thick-walled, spinose and spinulose cells, each of which can disarticulate and act as an asexual propagule, individually germinating to form dikaryotic hyphae. (Compare cherocytes to chlamydospores).

Chiastobasidium: A holobasidium that is clavate with nuclear spindles transverse across the basidium and located near the top of the basidium (Donk, 1964). See also holobasidium, stichobasidium.

Chitin (pronounced ky-tin or kite-in): The main component of the cell walls of fungi. The structure of chitin was solved by Albert Hofmann in 1930.

Chitinase (Pl. Chitinases): Hydrolytic enzymes that break down glycosidic bonds in chitin.

Chlamydosopores: A chlamydospore is the thick-walled big resting spore of several kinds of fungi including ascomycota such as *Candida* and basidiomycota such as *Panus*. It is the life-stage which survives in unfavourable conditions, such as dry or hot seasons. Chlamydospores are usually dark-coloured, spherical, and have a smooth (non-ornamented) surface. They are multicellular, the cells being connected by pores in septae between cells. Chlamydospores are a result of asexual (thus being actually conidia called chlamydoconidia) or sexual reproduction. Teliospores are special kind of chlamydospores of rusts and smuts.

Chromatic aberration (CA) (Synonymous with Achromatism or Chromatic Distortion): A type of distortion in which there is a failure of a lens or objective to focus all colors to the same convergence point. It occurs because lenses have a different refractive index for different wavelengths of light (the dispersion of the lens).

Chromatid: A chromatid contains the replicated DNA of each individual chromosome, which are joined by a centromere, for the process of cell division (mitosis or meiosis). They are normally identical ("homozygous") but may have slight differences in the case of mutations, in which case they are heterozygous. A chromatid is one of the two identical parts of the chromosome after S phase.

Chromophore: A chromophore is the part of a molecule responsible for its color. The color arises when a molecule absorbs certain wavelengths of visible light and transmits or reflects others. The chromophore is a region in the molecule where the energy difference between two different molecular orbitals falls within the range of the visible spectrum. Visible light that hits the chromophore can thus be absorbed by exciting an electron from its ground state into an excited state. In biological molecules that serve to capture or detect light energy, the chromophore is the moiety that causes a conformational change of the molecule when hit by light.

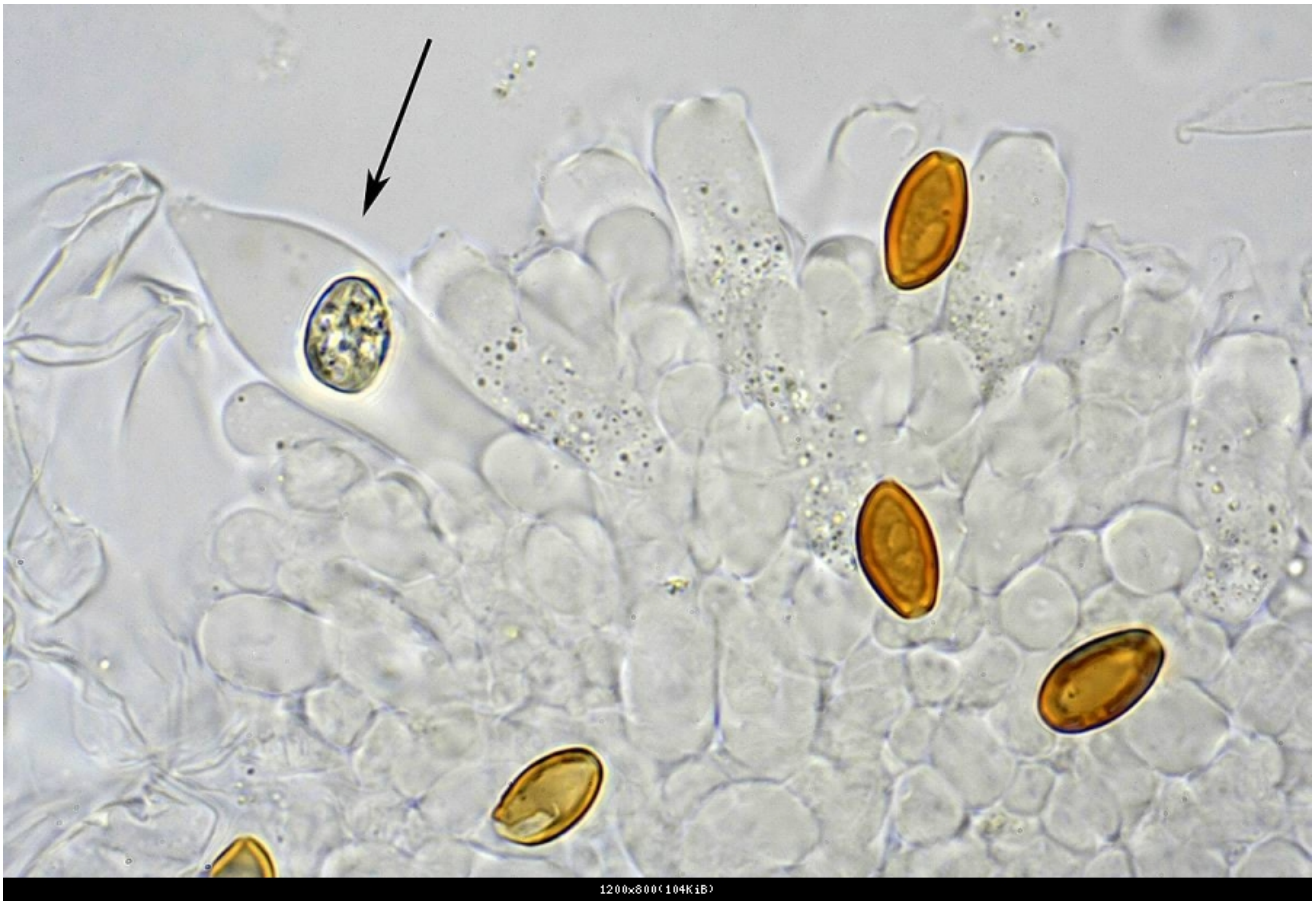
Chromosome: A chromosome is an organized structure of DNA and protein found in cells. It is a single piece of coiled DNA containing many genes, regulatory elements and other nucleotide sequences. Chromosomes also contain DNA-bound proteins, which serve to package the DNA and control its functions. Chromosomal DNA encodes most or all of an organism's genetic information.

Chromatograms (DNA sequencing chromatogram): A chromatogram (sometimes also called electropherogram) is the visual representation of a DNA sample produced by a sequencing machine.

Chronosequence: A set of forested sites that share similar attributes but are of different ages. Since many processes in forest ecology take a long time (decades or centuries) to develop, chronosequence methods are used to represent and study the time-dependent development of a forest. Field data from a chronosequence can be collected in a short period of several months. For example, chronosequences are often used to study the changes in fungi or plant communities during succession.

Chrysocystidium (pl., chrysocystidia): 1. Chrysocystidia are cystidia whose contents contain a distinct refractive yellow or golden body, that becomes more deeply yellow when exposed to KOH, ammonia or other alkaline compounds. Chrysocystidia are characteristic of many (though not all) members of the agaric family Strophariaceae. 2. Cystidium with yellow amorphous body or bodies in contents after treatment with NH4OH or KOH.

Below: Chrysocystidium viewed in 5% KOH courtesy Chemist Linas Kudzma (MO 312520 Stropharia hornemannii)



Chrysovessels (Chryso-Vessels): Hyphae that are similar to oleiferous hyphae (hyphae which don't contain latex but often contain a resinous material) but contain a granular to resinous material which turns yellow with alkaline reagents.

CI: PAUP Consistency Index (CI).

Ciliate Dermatocystidium: Dermatocystidia are terminal cells of the pellis that are distinctly different to the surrounding elements, a ciliate dermatocystidium consists of some short cylindrical basal cells which end in one or two terminal cells that are cylindrical or sometimes clavate and possibly subulate (ribbed), the apex of these terminal cells can be obtuse or acute.

Circumcystidia: Cystidia on the *margin* of the cap. Compare this term to pileocystidia and dermatocystidia.

Circumscription: In biological taxonomy, circumscription is the definition of the limits of a taxonomic group of organisms, a taxon. One goal of biological taxonomy is to achieve a stable circumscription for every taxon. Achieving stability is not yet a certainty in most taxa, and many that had been regarded as stable for decades are in upheaval in the light of rapid developments in molecular phylogenetics.

Citriniform: Lemon-shaped.

Clade: A clade is a group consisting of a species (extinct or extant) and all its descendants. The ancestor may be an individual, a breeding pair, a population or even a species (extinct or extant). In the terms of biological systematics, a clade is a single "branch" on the "tree of life". The idea that such a "natural

group" of organisms should be grouped together and given a taxonomic name is central to biological classification. In cladistics (which takes its name from the term), clades are the only acceptable units.

Cladogram: A cladogram is a diagram used in cladistics which shows relations among organisms. A cladogram is not however an evolutionary tree; many evolutionary trees can be inferred from a single cladogram. A cladogram uses lines that branch off in different directions ending at groups of organisms. There are many shapes of cladograms but they all have lines that branch off from other lines. The lines can be traced back to where they branch off and these branching off points are where a common ancestor is believed to have existed. Although traditionally such cladograms were generated largely on the basis of morphological characters, DNA and RNA sequencing data and computational phylogenetics are now very commonly used in the generation of cladograms.

Clamp: A hyphal outgrowth that connects two adjoining cells, resulting from a cell division bypassing the dividing cell wall.

Clamp Connections: A clamp connection is a structure formed by growing hyphal cells of certain fungi. It is created to ensure each septum, or segment of hypha separated by crossed walls, receives a set of differing nuclei, which are obtained through mating of hyphae of differing sexual types. It is used to create genetic variation within the hypha much like the mechanisms found in crozier during sexual reproduction. Swollen structure or loop located at the septa (cross-walls) of some Basidiomycetes' hyphae, involved in allowing nuclei to migrate into new cells after mitotic division.

Clasping-Cells (Clasping Cells): Abbreviated cl. Specialized (differentiated) hyphae cells located on the hymenial surface which clasp (strongly) the ends of a cystidium. Although some clasping cells are considered paraphyses, not all paraphyses are clasping cells (in fact, very few paraphyses function as clasping cells).

xyz

Above: Clasping cells at the hymenial surface holding in place a cystidium at both ends of each gill

Clasping Hyphal Branches: **xyz**

Class: In biological classification, class (Latin: classis) is a taxonomic rank. Other well-known ranks are life, domain, kingdom, phylum, order, family, genus, and species, with class fitting between phylum and order. As for the other well-known ranks, there is the option of an immediately lower rank, indicated by the prefix sub-: subclass (Latin: subclassis). A taxonomic unit, a taxon, in that rank. In that case the plural is classes (Latin classes). The composition of each class is determined by a taxonomist. Often there is no exact agreement, with different taxonomists taking different positions. There are no hard rules that a taxonomist needs to follow in describing a class, but for well-known animals there is likely to be consensus.

Clavate: Club-shaped.

Clavicutis: With reference to the cortical layer(s), the hyphae pattern is irregular with terminal cells being inflated and irregularly arranged.

Claviform: 1. Club-shaped. Clavate. 2. Cystidia which are basically narrow except for the swollen apex which scrarcely suggest a minute club.

Clearing Agent: The term "clearing" comes from the fact that the clearing agents often have the same refractive index as proteins. As a result, when a tissue is completely infiltrated with a clearing agent, it becomes translucent. Clearing agents may vary in effectiveness or completeness of the clearing process. Mycology-related clearing agents are currently being researched and may include KOH (Potassium Hydroxide), Chloral Hydrate, Visikol, Xylene, Histo-Clear, Lactic Acid, and Methyl Salicylate.

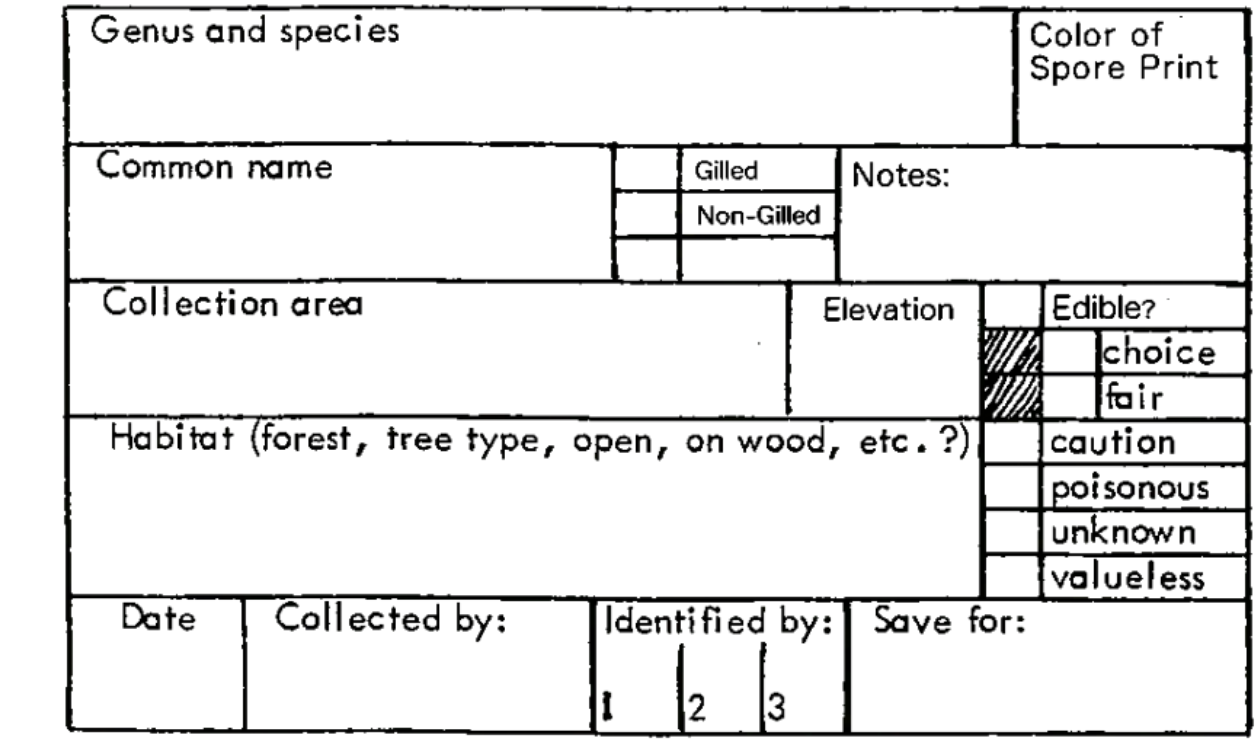
Clémençon's Solution: This is used to rehydrate dried fungi tissue and make it easier to cut sections. The formula is 80ml of 96% ethanol (or industrial methylated spirit), 20 ml of concentrated ammonia and 1gm of glycerol. The dried material is soaked in this until it is sufficiently softened. It is then removed and allowed to dry for a while when it should be "waxy" and able to be sectioned. A final soak in 10% ammonia may help to expand the section.

Clonotype: Herbarium specimens made from plants or fungi propagated from (and thus clones of) the same plant from which a type specimen was made. Clonotypes are of some use in documenting a type collection but have no status under the *International Code of Botanical Nomenclature*. (Compare to Holotype, Isotype, Lectotype, and Neotype).

Club Fungi: This is sometimes used as a very broad term - sometimes it's unhelpful and/or misused, describing any type of fungi that arises - even microscopically - with a fruiting structure. For mycologists who are interested in distinguishing the beautiful array of fungi existing on Earth, club fungi are now considered *clavarioid fungi* - a group of fungi in the Basidiomycota typically having erect, simple or branched basidiocarps (fruit bodies) that are formed on the ground, on decaying vegetation, or on dead wood. They are colloquially called club fungi and coral fungi.

Clustered: This term has been used two ways: Synonymously with *cespitose* or growing very closely together, but not with all the stems arising from a common point of origin.

Collection Card: A printed out card or piece of paper used to identify mushrooms at forays and mushroom festivals.



960x618 (52KiB)

Above: Collection card used at mushroom festivals

Collybioid: Based on Collybia (as opposed to Mycenoid based on Mycena). Refers to the overall stature and appearance of a mushroom.

comb.: Combination.

comb. et stat. nov.: Combination and status new.

comb. nov.: New combination.

Common Ancestor: The Earth is theorized to have formed around 4.2-4.5 billion years ago. Lifeforms began to emerge 3.5-3.8 billion years ago. As life developed, so did common ancestors. One of the these common ancestors is thought to have created three branches of life: Bacteria, Archaea, and Eukarya. The Eukarya include animals (humans are actually in this group), fungi, plants, slime molds, true slime molds, and stramenopiles. It should be noted that humans are closer related to fungi than to plants.

Complanate: Flattened or compressed.

Complex (Species Complex): A species complex is a group of closely related species, where the exact demarcation between species is often unclear or cryptic owing to their recent and usually still incomplete reproductive isolation. Ring species, superspecies and cryptic species complex are example of species complex. Such groups of species with complex relationship between species may occur in a line undergoing rapid speciation or where such speciaton recently have occurred, so that species separation mechanisms has yet to be fully developed. Such cases may leave some species paraphyletic at the species

level and to hybrid species, making phylogenetic analysis difficult. Species complexes are more common among plants, but animal examples exist, such as the dog-wolf-coyote complex (the genus Canis) and the cobras (genus Naja). Often such complexes only become evident when a new species is introduced into the system, breaking down existing species barriers. An example is the introduction of Spanish slug in Northern Europe, where interbreeding with the local black slug and red slug, traditionally considered clearly separate species that did not interbreed, shows these may actually be subspecies of the same species.

Compressed: (See complanate). Flattened.

Concolorous: Not comparable in color. Colored the same throughout.

Condenser Diaphragm (Synonymous with Iris Diaphragm): A condenser is one of the main components of the optical system of many transmitted light compound microscopes. A condenser is a lens that serves to concentrate light from the illumination source that is in turn focused through the object and magnified by the objective lens. It is a basic component of almost all compound light microscopes manufactured since the 19th Century. An equivalent condenser, which focuses an electron beam, is a basic component of both transmission and scanning electron microscopes.

Conducting Tissue: Tissues that secrete and excrete substances.

Confluent: Flowing together; blended into one. Going towards the same point.

Congeneric: Belonging to the same taxonimic group; belonging to the same genus.

Congophilus: Spore wall accumulating congo red stain.

Conico-Papillate: Resembling a cone and a cylinder in a nipple-like form.

Conidia (Conidium): Are asexual, non-motile spores. They are also called mitospores due to the way they are generated through the cellular process of mitosis. Spores found on the mycelium (versus spores found on the sporocarp). Some gilled mushrooms develop conidia.

Conidiogenesis: The production of conidia by hyphae.

Coniferous: Of, relating to, or belonging to the plant phylum Coniferophyta (Conifer). Involving any of various mostly needle-leaved or scale-leaved, chiefly evergreen, cone-bearing gymnospermous trees or shrubs such as pines, spruces, and firs.

Conioderm: With reference to the cortical area, the cells are spherical and in several layers.

Connate: Joined or united with a structure of the same kind.

Connective Tissue: Generative and other rapidly growing elements.

Connective Hyphae: Usually narrow, undifferentiated hyphae of the context of basidiocarp connecting all

other elements (used in opposite of fundamental hyphae).

Conspecific: Of the same species.

Conspicuous Polymorphous Pleurocystidia:

Constituent Hyphae: Hyphae relevant to a saprophytic or heterotrophic relationship.

Context: Flesh of cap or stem (excluding the surface layer).

Contextual Hyphae: Hyphae residing in the pileus.

Contig (Pl. Contigs): A set of overlapping DNA segments that together represent a consensus region of DNA. In bottom-up sequencing projects, a contig refers to overlapping sequence data (reads); in top-down sequencing projects, contig refers to the overlapping clones that form a physical map of the genome that is used to guide sequencing and assembly. Contigs can thus refer both to overlapping DNA sequence and to overlapping physical segments (fragments) contained in clones depending on the context.

Convergent Gill Trama: Of gill hyphae, projecting inward and downward away from cap as seen in cross-section.

Convergent Lamellar Hyphae: Hyphae converging towards the center of the trama.

Coprophilous Fungi (Coprophiles, Cophrophillic): Growing on or from dung. Coprophilous fungi are a type of saprobic fungi that grow on animal dung. The hardy spores of coprophilous species are unwittingly consumed by herbivores from vegetation, and are excreted along with the plant matter.

Coralloid: Coral-shaped. May refer to coralloid projections from a cell or a group of cells, or to coralloid fungi (macroscopic forms of fungi resembling corals such as those found in the genus Ramaria).

Coralloid Subhymenium: A type of subhymenia in which the cells are shaped irregularly with many projections which do not connect to their cells.

Cordate: Heart-shaped.

Cordon: Resembling a pseudorhiza.

Cornuate: (See "Barbellate"). Horn-shaped.

Coronate: Crowned.

Cortex: With reference to a cortical layer, a denser trama context which is sometimes pigmented or somewhat gelatinous.

Cortical Layers: Outermost layers of a mushroom basidiome. Usually used to reference the layers of the pileipellis, but can refer to the stipitipellis (and the bulbipellis) as well, but excludes any veil or veil

parts.

Cortina: A cobwebby partial veil consisting of silky fibrils. This is very common in the genus *Cortinarius*.

Cortina Remnants: A very small amount of left over cortina material left on the stem.

Cortinariaceae: The *Cortinariaceae* are a large family of gilled mushrooms found worldwide, containing over 2100 species. The family takes its name from its largest genus, the varied species of the genus *Cortinarius*. Many genera formerly in the *Corinariaceae* have been placed in various other families, including *Hymenogastraceae*, *Inocybaceae* and *Bolbitiaceae*. The deadly toxin orellanine has been found in at least 34 *Cortinariaceae*. The equally deadly toxin amanitin has also been found in at least seven *Cortinariaceae*.

Cortinate: With a cortina, weblike. A cobwebby remnant of the partial veil which in some mature mushrooms hang from the edges of the cap and connect to the stipe.

Cortinate Partial Veil: A partial (incomplete) veil extending - approximately - from the margin of the cap to the stem which was ruptured by growth or had never formed a fully intact veil.

Coscinocystidia: The end cells of a coscinoid. Not found in gilled fungi.

Coscinoids: Dark colored conducting system with winding perforations or holes inside otherwise solid filaments. 2. Highly pigmented conducting elements with an abundance of sieve-like pores in the hyphal surfaces and septa.

Costate: Having ridges. Typically with the pileus or stipe surfaces.

Cover Slip (Cover Glass): A cover slip is the thin piece of glass or plastic that covers a specimen mounted on a slide. It protects both the objective and the specimen. The thickness of this small glass piece is now standardized at 0.17mm for most applications.

Crassobasidia: Basidia producing crassospores. These basidia are also thick-walled.

Crassospores: Found very rarely in a few Amanita species. Thick-walled decorated by rather evenly distributed pits.

Creeping Aerial Mycelium: Mycelium in a petri dish that grows upward along the clear edges of the dish.

Crenate: With rounded teeth.

Crenulate: Minutely crenate.

Crepidotoid (Synonymous with Pleurotoid): Stem reduced, laterally inserted of even lacking; cap usually flattened, and circular to kidney shaped when seen from above.

Cristulee: Small chains on the spores as seen in Melzer's.

Cross Section: A surface or shape that is or would be exposed by making a straight cut through something, esp. at right angles to an axis.

Crown Group: In phylogenetics, the crown group of a collection of species consists of the living representatives of the collection together with their ancestors back to their most recent common ancestor as well as all of that ancestor's descendants. It is thus a clade, a group consisting of a species and all its descendants.

Crush Mount (Syn. Smash Mount): The goal of a crush mount is to get cells to break free so that each entire cell can be viewed (whether it's for basidium, cheilocystidium, pleurocystidium, etc). Put the best material available on a slide with an appropriate amount of KOH solution (soap water and other liquids work for this too) - then add a cover slip. Press down with a pencil eraser to gently flatten the material and vanish any air bubbles. The goal is to free up the cells (basidia, cystidia, etc) so they can be viewed with better visibility. You have to utilize the appropriate amount of pressure to get good visibility but not so much that you destroy the sample. It can take several attempts and requires a bit of patience. Too little pressure and the cells are not freed. Too much and the cystidia are crushed. Note: It helps to cover your finger with a kimwipe/tissue/paper towel and press down semi-hard on the cover slip. The squash forces extra water out from under the cover slip and can sometimes rise onto the cover slip.

Crusto-: Resinous (Resembling resin or containing resin).

Cryptbox: Bulky cryptogam specimens that require protection in a box, e.g. fungal fruiting bodies.

Cryptic Species: In scientific classification, a cryptic species complex is a group of organisms that are typically very closely related yet their precise classification and relationships cannot be easily determined by molecular phylogenetic studies. If lineage sorting has not yet been completed, members of a cryptic species complex widely share plesiomorphic haplotypes, because individual species have not yet evolved distinctive autapomorphic mutations. But usually, individual species within the complex can be separated by analysing data from multiple sources, such as by comparing polytene chromosomes, DNA sequence analyses, bioacoustics and thorough life history studies. They may be parapatric, are frequently sympatric, and are sometimes allopatric. Cryptic species complexes are not the same as populations undergoing speciation: they typically represent a situation where speciation has already broken the gene flow between populations, but where evolution has not progressed to a point where easily recognizable adaptations have taken place. Cryptic species that do not form a complex may be somewhat more distantly related and simply represent lineages that have been so successful as to require little evolutionary change, possibly coupled with parallel evolution. A famous example outside the realm of mycology can be seen in the Eurasian and Short-toed Treecreepers, perhaps the first cryptic species to be recognized as such. Other ornithologists refused to accept that more than one species was involved until Brehm presented his bioacoustic studies, which left no room for doubt. The European Treecreeper has since been found to be a very close relative of the Himalayan Hodgson's Treecreeper, while the Short-toed Treecreeper is probably the sister species of the North American Brown Creeper. Cryptic species are also common in certain families of insects such as Chironomidae. A related concept is the superspecies. This is a clade of at least two more or less distinctive species with approximately parapatric distributions. Not all cryptic species complexes are superspecies, and vice versa, but many are.

Crystalline Initials: Emerging crystal or crystal like substance, found so-far in young sclerotia and visible via high magnification microscopy.

Crystals: Some cystidia have crystals, including calcium oxalate crystals.

Cuboid: (Shape of spores). A cuboid is a box-shaped solid object. It has six flat sides and all angles are right angles. And all of its faces are rectangles.

Cucurbitiform (Synonymous with Lageniform and Sicyoid): Shaped like a flask.

Cuneate: Wedge-shaped.

Cuticle: The skin, or outer layer, of the fruiting body is called the cuticle. Pellis and derm are synonyms. These terms can be combined with others to give indications as to where the skin is. For example, pileipellis means the skin of the cap. Stipitipellis is the skin of the stipe. Cuticle may refer to the stipe or pileus outer hyphal formation.

Cutis: If the hyphae making up the cuticle lie more or less flat on the surface of the mushroom, the term ends in -cutis.

Cyanophilic: Spore or hyphal wall staining dark blue in cotton blue.

Cyanophilic Basidia: Basidia staining dark blue in cotton blue.

Cyanophilic Basidiospores: Spores staining dark blue in cotton blue.

Cyanophilic Hyphae: Hyphae staining dark blue in cotton blue.

Cylindric (Cylindrical): 1. Of the same diameter throughout its length; of stem, terete (not compressed); of spores, according to one set of criteria ratio of length to width 2-3: less would be oblong, more would be bacciliform. 2. Spore Q=2.0-3.0.

Cylindro-Clavate: Cystidia which are basically cylindrical yet the swollen apex gives it the shape of a small club.

Cyphelloid: Basidiocarps that are disc-, tube-, or cup-shaped; cupulate basidiomycete fruitbody morphology. This term has been used at least once to describe a phenotype of gilled mushrooms which have up-turned caps forming a cup-like shape.

Cystide En Brosse: Cystidia with prolongations and diverticulae. May cover acanthophysoid and dendrophysoid structures.

Cystidia: A cystidium is a big, funny-looking end cell that sticks out of a gill surface but doesn't look like a basidium. Since cystidia have so many shapes, and these shapes hold (fairly) constant for a given species, they are useful in identifying mushrooms. What they are and what they do is still being investigated within each species.

Cystidia-Like Hyphae: Multicellular structures which project into the hymenium. The two categories of cystidia-like hyphae are Cheilocatenulae and Cystidiod Hyphae. (See respective definitions).

Cystidioid Hyphae: Similar to cheilocatenulae except the elements of the cystidium-like hypha are not differentiated.

Cystidioid Elements: (definition needs adjustments) A synonym to describe cystidia-like cells on the pilleipellis (similar to pileocystidia).

Cystidioles: 1. Cystidia which are immature, aborted, arrested in development. 2. A sterile cell. Either an undifferentiated or immature cystidium or a slightly enlarged or modified sterile basidium. Considered by some to be true cystidia which originate at the level as basidia and differ only slightly in size and/or shape from basidia and brachycystidia.

Cystidium (pl. cystidia): Sterile, differentiated, terminal element in the hymenium, or on the surfaces of the basidiocarp. Also see the above definition for *cystidia*.

Cystoderm: Synonym for cellular. Composed of sphaerocytes; a velar structure overlaying the pileipellis. A pileipellis composed of rounded cystidia-like elements. Applied to pellis consisting of rounded elements; same as polycystoderm.

Cytoplasm: The cytoplasm is the gel-like substance residing within the cell membrane holding all the cell's internal sub-structures (called organelles), outside the nucleus.

Cytoplasmic Pigments: Restricted to the cytoplasm. Appearing as more or less uniform color in the hyphae.

Cytoskeleton: The cytoskeleton (also CSK) is a cellular scaffolding or skeleton contained within a cell's cytoplasm. The cytoskeleton is present in all cells; it was once thought to be unique to eukaryotes, but recent research has identified the prokaryotic cytoskeleton. It forms structures such as flagella, cilia and lamellipodia and plays important roles in both intracellular transport (the movement of vesicles and organelles, for example) and cellular division. In 1903 Nikolai K Koltsov proposed that the shape of cells was determined by a network of tubules which he termed the cytoskeleton.

Dacryform: Tear-drop shaped.

Daedaleoid: Maze-like in appearance.

de nova: In general usage, de novo is a Latin expression meaning "from the beginning," "afresh," "anew," "beginning again."

Deciduous: Deciduous means "falling off at maturity" or "tending to fall off", and is typically used in reference to trees or shrubs that lose their leaves seasonally, and to the shedding of other plant structures such as petals after flowering or fruit when ripe. In a more general sense, deciduous means the dropping of a part that is no longer needed, or falling away after its purpose is finished. In plants it is the

result of natural processes. Deciduous has a similar meaning when referring to animal parts, such as deciduous antlers in deer, or deciduous teeth, also known as baby teeth, in some mammals (including human children). In botany and horticulture, deciduous plants, including trees, shrubs and herbaceous perennials, are those that lose all of their leaves for part of the year. This process is called abscission. In some cases leaf loss coincides with winter - namely in temperate or polar climates. In other parts of the world, including tropical, subtropical, and arid regions, plants lose their leaves during the dry season or other seasons, depending on variations in rainfall. The converse of deciduous is evergreen, where green foliage is persistent year round. Plants that are intermediate may be called semi-deciduous; they lose old foliage as new growth begins. Other plants are semi-evergreen and lose their leaves before the next growing season, retaining some during winter or dry periods.

Decurrent: Gills descending down the stipe.

Above: Decurrent gills; gills that are directly attached to the stipes, descending down the stipes. *Lactarius olympianus*

Delimit (Delimiting): To establish the limits or boundaries of; demarcate.

Deliquescent (Deliquesced, Deliquescence, Autodigestion): To become fluid upon maturing. Auto-digesting. Self-digesting. Compare to observations of inky cap fungi.

Dendroid: Tree like or having many branches.

Dendrophysis: 1. Hyphoid with tree-like branching. 2. A hyphal thread with arboreal branching.

Dendrophysoid: 1. This term is usually applied sparingly to describe hyphae or cystidia with branches, bringing about a somewhat tree-like appearance to the hyphae. 2. Thin walled narrow hyphae, branched or with spurs - located in the outer layers of the stipe. In some species dendrophysoid hyphae or cystidia have only been observed when stained with cotton blue.

Dendrophysoid Layer: A branching layer of hyphae in which outgrowths of shorter hyphae grow from the main, larger hypha cells.

Deprecate: To express disapproval of (usually in reference to a particular species name which is deprecated so that another species name is now used in place of the old one.

Depth of Field (DOF): The distance between the nearest and farthest objects that appear acceptably sharp/clear. When depth of field is insufficient to get a clearly focused image of a whole object, focus stacking can be used.

Derm: Surface layer of cap cells if they are differentiated from the underlying tissue and arranged more or less perpendicular to cap surface: if the elements are a single row or roundish cells, this is a cellular derm; if cells are elongated and all reach the same level, this is a palisoderm; if cells are elongated and of different lengths, it is a trichoderm; the prefix ixo- can be added to indicate that elements are gelatinized.

Dermatobasidia: Basidia with sterigmata visible in the center.

Dermatocystidium (Pl., Dermatocystidia): Sterile cell (cystidium) on the cap surface or the stem surface. There are two types: Pileocystidia (sometimes called pilocystidia) and Caulocystidia.

Det.: Determined by. Commonly used on herbarium collection cards after a mycologist identifies the collection. The mycologist/biologist who made the determination is presented with the Det., followed by the date of determination.

Deuterocystidia: Endosecretory cells.

Deuteroplasm (Synonymous with Deutoplasm): The non-active material in cytoplasm or protoplasm.

Dextrinoid (Dextrinoidy): 1. A term used to describe a color change which can occur with some spore prints mounted in Melzer's reagent, Iodine, or Lugol's Dilute Solution. The color will change to reddish brown. 2. Staining yellowish brown or reddish brown in Melzer's reagent (Source - http://forestry-dev.org/biodiversity/matchmaker/glossary/D_e.html)

Diagnostic Keys: Dichotomous key but not identical to a "Synoptic Key." Keys that concentrate on making identification most convenient and reliable. Keys that limit the choice of characteristics to those most reliable, convenient, and available under certain conditions. Multiple diagnostic keys may be offered for the same group of organisms: Diagnostic keys may be designed for field (field guides) or laboratory use, for summer or winter use, and they may use geographic distribution or habitat preference of organisms as accessory characteristics.

Diaphragm (Condenser Illuminating Aperture Diaphragm): This part controls the effective size of the condenser aperture.

DIC Microscopy: Differential interference contrast microscopy (DIC), also known as Nomarski Interference Contrast (NIC) or Nomarski microscopy, is an optical microscopy illumination technique used to enhance the contrast in unstained, transparent samples.

Dichophysis: Hyphoid that is dichotomously branched.

Dichotomous Keys (Synonym Single Access Key): A key where the sequence and structure of identification steps is fixed by the author of the key. At each point in the decision process, multiple alternatives are offered, each leading to a result or a further choice. The alternatives are commonly called "leads", and the set of leads at a given point a "couplet". If the key has several choices it is described as polychotomous or polytomous. If the entire key consists of exactly two choices at each branching point, the key is called dichotomous. The majority of single-access keys are dichotomous.

Dieback (Die Back): In reference to a mycelium that halts its hyphal growth with the outer, peripheral cells dying and the process progressing inward.

Difference: Spore length minus spore width.

Digitate: Shaped like a spread hand. Cystidium with two to several finger-like, apical protuberances; the remaining portion of the cell is usually swollen.

Dikaryon: Having two nuclei as opposed to one or more than two nuclei. 1. A pair of associated but unfused haploid nuclei of a fungus cell capable of participating in repeated cell division as separate entities prior to their ultimate fusion 2. A cell having (or a mycelium made up of) cells each having a dikaryon.

Dikaryotic: The state in certain fungi in which each compartment of a hypha contains two nuclei, each derived from a different parent.

Dikaryotization: The conversion of a homokaryon into a dikaryon usually by the fusion of two compatible homokaryons.

Dimitic: 1. A category of trama hyphae having two kinds of hyphae: The first is generative with binding hyphae. The second is skeletal hyphae (which are thick-walled, unbranched, aseptate, and straight to slightly flexuous; the lumen is more or less obliterated except sometimes at the apices where walls are thin and enclose dense contents.) Contrast the term *dimitic* with *monomitic* and *trimitic*. 2. Trama composed of generative and skeletal hyphae in the narrowest sense (i.e. thick-walled, un-branched, aseptate, straight or slightly flexuous, longitudinal hypahe with the lumen more or less obliterated in mature parts, but the apices thin-walled with dense contents).

Dimorphic: 1. Occurring in two distinct forms. 2. Combining qualities of two kinds of individuals in one. 3. Sexual dimorphism is a phenotypic difference between males and females of the same species. Examples of such differences include differences in morphology, size, ornamentation and behavior.

Diploid: Making an exact duplicate. When one cell makes another cell of identical data/contents/appearance. Containing all the needed chromosome data to be a complete cell and creating an identical one. (Compare to haploid).

Disc (Synonymous with Disk): The center of the top surface of the cap.

Distal (Distal End): The apex of the basidiospore; away from the sterigmata; where the germ pore is located; opposite to the apiculus. The apical end of the spore.

Distribution (Synonymous with Range): The geographical area(s) in which a species can be found.

Divergent Gill Trama: (Of hyphae of a mushroom gill) 1. Having lateral strata angled away obliquely from a central strand (mediostratum) of vertically oriented hyphae. 2. Hymenophoral trama having downward hyphae turning outward from a median line.

Divergent Lamellar Hyphae (Bilateral Lamellar Trama): After creating a gill cross section to view the lamellar trama, imagine a line running down the top (near the cap) to the bottom tip of each gill. The two halves of the gill divided by that line are approximate mirror images of each other and the tissues on both sides of the center line are composed of cells that individually and in groups are clearly curving away from the center line.

Diverticulate (Diverticule, Diverticules, Diverticulum, Diverticuli): 1. Having short offshoots approximately at right angles to the main stem. 2. To turn aside; to turn 3. A spore that has a prominent little depression and point where it was attached to its basidium. 4. Taking many directions from a single source. The directions formed are distinct patterns that may resemble branches. It therefore means forming a branch like pattern from a single source, like a river.

Diverticulate Cystidia: Cystidia which have numerous peg-like protuberances located either over the apical portion or over the entire surface.

Diverticulate Elements: Some species (including species in the genus Coprinellus) have hyphal elements on the cap surface that branch more or less frequently, similar to velar elements of Coprinopsis section Alachuani. They are less branched (never coralloid) than in species in section Alachuani, but they can be noticed on the cap surface as hyphae, standing out from the rest of the cap surface in species that have them (e.g. C. hiascens). Sometimes it's difficult to notice them.

Diverticulate Hyphae: With many apical branched or contorted protrusions.

DNA Barcoding (DNA Barcode): DNA barcoding is a taxonomic method that uses a short genetic marker in an organism's DNA to identify it as belonging to a particular species. It differs from molecular phylogeny in that the main goal is not to determine classification but to identify an unknown sample in terms of a known classification. Although barcodes are sometimes used in an effort to identify unknown species or assess whether species should be combined or separated, the utility of DNA barcoding for these purposes is subject to debate. Check: http://www.kew.org/science-research-data/directory/projects/FungalDNABarcoding.htm and http://barcoding.si.edu/dnabarcoding.htm

DNA Extraction (DNA Isolation): DNA isolation is a process of purification of DNA from sample using a combination of physical and chemical methods. See Molecular Ecology Resources (2010) 10, 628–633 for more.

DNA Fingerprinting: DNA fingerprinting, also called DNA typing, in genetics, method of isolating and making images of sequences of DNA (deoxyribonucleic acid). The technique was developed in 1984 by the British geneticist Alec Jeffreys, after he noticed the existence of certain sequences of DNA (called minisatellites) that do not contribute to the function of a gene but are repeated within the gene and in other genes of a DNA sample. Jeffreys also determined that each organism has a unique pattern of these minisatellites.

DNA Polymerase: The enzyme responsible for DNA replication. Any of various enzymes that function in the replication and repair of DNA by catalyzing the linking of nucleotides in a specific order, using single-stranded DNA as a template.

DNA Regions For Sequencing: This is a broad term used to summarize common fungal DNA regions used for taxonomy such as the ITS1, ITS2, complete ITS barcode region, CO1, COX1, EF1 Alpha, RPB1, RPB1-intron 2, RPB2, 18S, 25S, Small Subunit ribosomal RNA, and the Large Subunit
ribosomal RNA region.

DNA Sequence (Used sometimes synonymously with Genetic Sequence and Nucleic Acid Sequence): A nucleic acid sequence is a succession of letters that indicate the order of nucleotides within a DNA (using GACT) or RNA (GACU) molecule. By convention, sequences are usually presented from the 5' end to the 3' end. Because nucleic acids are normally linear (unbranched) polymers, specifying the sequence is equivalent to defining the covalent structure of the entire molecule. For this reason, the nucleic acid sequence is also termed the primary structure.

DNA Sequencing: DNA sequencing is the process of reading the nucleotide bases in a DNA molecule. It includes any method or technology that is used to determine the order of the four bases—adenine, guanine, cytosine, and thymine—in a strand of DNA.

Dolipores (Dolipore Septum): Dolipores are a part of the septa - located at the central opening connection between septa. A type of septum found in many basidiomycete fungi, in which there is a narrow pore surrounded by a thickened rim and protected on both sides by caps. Each septum is characterized by a swelling around the central pore (dolipore).

Domain: 1. In biological taxonomy, a domain (also superregnum, superkingdom, empire, or regio) is the highest taxonomic rank of organisms, higher than a kingdom. According to the three-domain system of Carl Woese, introduced in 1990, the Tree of Life consists of three domains: Archaea, Bacteria and Eukarya. The arrangement of taxa reflects the fundamental differences in the genomes. 2. Domain also can refer to an area of DNA being studied: A DNA-binding domain (DBD) is an independently folded protein domain that contains at least one motif that recognizes double- or single-stranded DNA. A DBD can recognize a specific DNA sequence (a recognition sequence) or have a general affinity to DNA. Some DNA-binding domains may also include nucleic acids in their folded structure.

Dorsal: Adaxial side of spore. Side inner most to the axis of the basidium.

Dorsiventral: Flattened and having distinct upper and lower surfaces, as most leaves do.

Double Annulus: Annulus composed of two distinct layers of tissue, with the lower layer being typically cottony or fibrillose.

Dual Nomenclature (Dual System): The use of more than one name for a single taxon, was established in the International Code of Botanical Nomenclature (ICBN/ICN) in 1910, to accommodate the problem of naming fungi that exhibit pleomorphic life cycles (Cline 2005). Article 59 of the ICBN/ICN governs the naming of these fungi. The Article has implication for many common fungi that are holomorphic, i.e. that produce both a teleomorph and an anamorph. Dual nomenclature has permitted the use, for any taxon, of either the telomorph or the anamorph name as appropriate.

Dikaryotic: The state in certain fungi in which each compartment of a hypha contains two nuclei, each derived from a different parent.

e.g.: "E.g." means "for example" and comes from the Latin expression exempli gratia, "for the sake of an example."

E-Value: In DNA BLAST results the E-Value represents Expect (E) Value. The Expect value (E) is a parameter that describes the number of hits one can "expect" to see by chance when searching a database of a particular size. It decreases exponentially as the Score (S) of the match increases. Essentially, the E value describes the random background noise. For example, an E value of 1 assigned to a hit can be interpreted as meaning that in a database of the current size one might expect to see 1 match with a similar score simply by chance. The lower the E-value, or the closer it is to zero, the more "significant" the match is. However, keep in mind that virtually identical short alignments have relatively high E values. This is because the calculation of the E value takes into account the length of the query sequence. These high E values make sense because shorter sequences have a higher probability of occurring in the database purely by chance. For more details please see the calculations in the BLAST Course. The Expect value can also be used as a convenient way to create a significance threshold for reporting results. You can change the Expect value threshold on most BLAST search pages. When the Expect value is increased from the default value of 10, a larger list with more low-scoring hits can be reported.

Eccentric Germ Pore (Germ Pore Eccentric): Spores with off-centered germ pore.

Echinate: Having spines or structures similar to spines. (Example: Spores of Laccaria laccata).

Echinulate: Having small sharply pointed spines.

Echinidia: Often applied to the shortened broom cell.

Ecology: The scientific study of the relationships that living organisms have with each other and with their natural environment.

Ectomycorrhizal: The mycelia of mycorrhizal mushrooms can form an exterior sheath covering the roots of plants. The sheath is called ectomycorrhizal. When the mycelia continues to develop and invades the interior root cells of host plants they are called endomycorrhizal. Ectomycorrhizal mushrooms include some species of Laccaria, Lyophyllum, Cortinarius, Inocybe, Dermocybe, Tricholoma, Entoloma, Amanita, and others.

Ectomycorrhizal Sheath (Ectomycorrhizal Sheaths): Ectomycorrhizas consist of a hyphal sheath, or mantle, covering the root tip and a Hartig Net of hyphae surrounding the plant cells within the root cortex. In some cases the hyphae may also penetrate the plant cells, in which case the mycorrhiza is called an ectendomycorrhiza. Outside the root, ectomycorrhizal extramatrical mycelium forms an extensive network within the soil and leaf litter.

Ectosporium: The outer, very thin layer of the spore wall.

eds.: Abbreviator either editors or editions.

EF-1a (ef-1α): Subfamily of elongation factors used in DNA sequencing. (Elongation factors are a set of proteins that are used in protein synthesis in the cell.)

Effectively Published: (Reference to publishing a new species). Please see http://www.imafungus.org/Issue/2/13.pdf

Elements of Veil: Parts or areas of the veil.

Ellipsoid: 1. A three-dimensional geometric figure resembling a flattened sphere. 2. Spore Q=1.3-1.6. 3. Cystidia Q=1.3-1.6.

Elliptical: Having the shape of an ellipse.

Elongate (Synonymous with Oblong): 1. Long in relation to width; elongated: "elongate, fishlike creatures." 2. Spore Q=1.6-2.0.

Emarginate: Gills notched near the stipe.

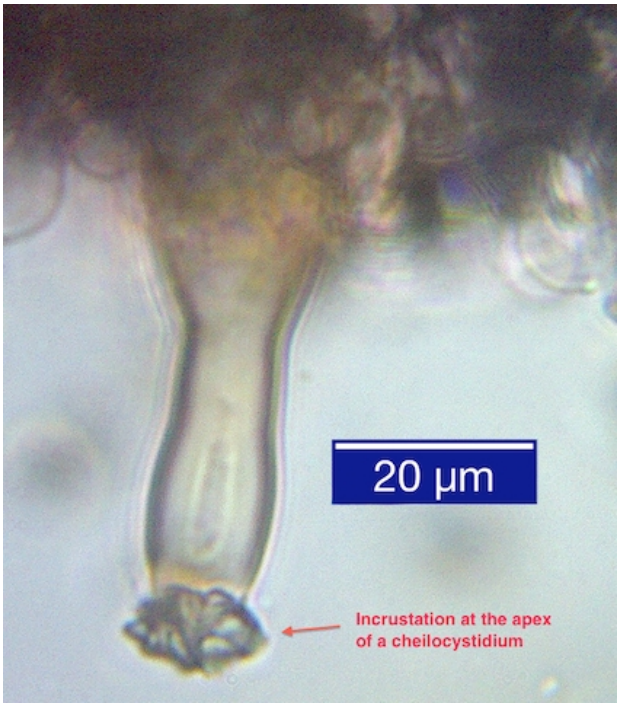
emend.: Abbreviated for "emended by". Make corrections and improvements to.

En Brosse: Cystidia with excrescences, diverticulate.

ENCB: Escuela Nacional de Ciencias Biológicas (National School of Biological Sciences). Herbarium in Mexico City, Mexico. Herbaria of the Escuela Nacional de Ciencias Biologicas. The Herbarium of the National School of Biological Sciences, Mexico.

Encrusted (Incrusted): Covered with a thin, hard crust. In hyphae, with matter located on their outer wall. In cystidia, covered with crystalline or amorphous deposit, particularly at the apex.

Below: Incrustation at the apex of a cheilocystidium



Endemic: Endemism is the ecological state of being unique to a defined geographic location, such as an island, nation or other defined zone, or habitat type; organisms that are indigenous to a place are not endemic to it if they are also found elsewhere. The extreme opposite of endemism is cosmopolitan distribution.

Endocystidia (Synonymous with Tramal Cystidia): 1. Cystidia in the cortex of the pileus trama, hymenophoral trama, or stipe trama. 2. Chrysocystidia embedded in the hymenophoral trama found in species of Pholiota, Stropharia, and Hypholoma.

Endomembrane System: The endomembrane system is composed of the different membranes that are suspended in the cytoplasm within a eukaryotic cell. These membranes divide the cell into functional and structural compartments, or organelles. In eukaryotes the organelles of the endomembrane system include: the nuclear envelope, the endoplasmic reticulum, the Golgi apparatus, lysosomes, vacuoles, vesicles, endosomes and the cell membrane. The system is defined more accurately as the set of membranes that form a single functional and developmental unit, either being connected directly, or exchanging material through vesicle transport. The endomembrane system does not include the membranes of mitochondria and chloroplasts.

Endomycorrhizal: The mycelia of mycorrhizal mushrooms can form an exterior sheath covering the roots of plants called *ectomycorrhizal*. When the mycelia continues to develop and invades the interior root cells of host plants they are called *endomycorrhizal*.

Endophytic: A wide diversity of fungi are isolated from the tissues of most terrestrial and aquatic plants, and red and brown algae. Fungi are present in most plant parts, especially the leaves. Where the tissue is apparently healthy, the fungi may be either endophytes or latent pathogens. Endophytes are contained within the plant without disease. Plant tissues remain entire and functional. However, some endophytes may also be isolated from the surface of leaves, indicating an unclear separation between endo- and epiphytic life form.

Endosporium: Reference to the spore wall. The electron transparent inner layer of the basidiospore wall at the inside of the episporium, but lacking in many white and pale-spored taxa.

Enterocutis: A cutis composed of swollen cells.

Entire: margin of pileus that is not rimose or striate.

Ephemeral Annulus: An annulus that exists only for a short duration.

Ephemeral Subannulus (Subpersistent Subannulus): A subannulus (resembling an annulus but not a true annulus resulting from the partial veil) lasting a very short time as seen in Psilocybe zapotecorum.

Epicutis: The outermost layer of the pileus pellis ("cuticle"), properly called the suprapellis.

Epicutis Scalp Section: A very thin slice of material taken from the top layer of the pileus, sometimes from the center of the cap.

Epidermoid Cutis: With reference to the cortical layer(s), the hyphal cells are inflated and often possess a puzzle-like or epidermoid appearance and are interlocked.

Epigenetics (Epigenetic Studies): In biology, and specifically genetics, epigenetics is the study of heritable changes in gene expression or cellular phenotype caused by mechanisms other than changes in the underlying DNA sequence. It refers to functionally relevant modifications to the genome that do not involve a change in the nucleotide sequence. Examples of such modifications are DNA methylation and histone modification, both of which serve to regulate gene expression without altering the underlying DNA sequence. These changes may remain through cell divisions for the remainder of the cell's life and may also last for multiple generations. However, there is no change in the underlying DNA sequence of the organism; instead, non-genetic factors cause the organism's genes to behave (or "express themselves") differently. See "epi-marks."

Epi-Marks: This definition is in need of modification. Epi-marks constitute an extra layer of information attached to gene backbones that regulates their expression. While genes hold the instructions, epi-marks direct how those instructions are carried out - when, where and how much a gene is expressed during development. Epi-marks are usually produced anew each generation, but recent evidence demonstrates that they sometimes carry over between generations and thus can contribute to similarity among relatives, resembling the effect of shared genes.

Epiphytes: Fungi that exist on the surfaces of plants are called epiphytes.

Episporium: The layer of the spore that is usually the thickest, giving the spores their form and rigidity, outside the endosporium and inside the exosporium.

Epithelium (Synonymous with Conioderm and Polycystoderm): 1. A type of cellular pellis in which elements are in chains so that the pellis is many-layered. 2. The outer surface of the cap layer type, having a spherical series of cells and possessing layers.

Epithet: Any word or phrase applied to a person or thing to describe an actual or attributed quality: “Richard the Lion-Hearted” is an epithet of Richard I.

Epitype: Under the ICBN/ICN, an additional and clarifying type could be designated, an epitype under §9.7 of the Vienna Code, where the original material is demonstrably ambiguous or insufficient.

Epitypified: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2565750/

Equilateral: Having all its sides of the same length.

Erect Hyphae: Hyphae or projections of hyphae that are perpendicular to the surface of the pileus.

Et. (et.): Latin for "and." Used in scientific papers when two authors are listed together (on some occasions).

Et Al.: Translated to "and others." Used in lower case: "et al."

et comb. stat. nov.: And combination status new.

Ethnomycological Studies (Ethnomycology): Ethnomycology is the study of the historical uses and sociological impact of fungi (a.k.a. "fungi lore") and can be considered a subfield of ethnobotany or ethnobiology. Although in theory the term includes fungi used for such purposes as tinder, medicine (medicinal mushrooms) and food (including yeast), it is often used in the context of the study of psychoactive mushrooms such as psilocybin-containing mushrooms, ergot and Amanita muscaria. By analogy to the term entheogen, the term "entheomycology" (ἔνθεος entheos meaning literally "god within", more freely translated "inspired") has been suggested for the study of psychoactive mushrooms used for spiritual purposes.

ETOH: Ethyl Alcohol.

ETS (ETS Region): External Transcribed Spacer. External transcribed spacer (ETS) refers to a piece of non-functional RNA, closely related to the internal transcribed spacer, which is situated outside structural ribosomal RNAs (rRNA) on a common precursor transcript. (Compare to ITS).

Etymology: Etymology is the study of the history of words, their origins, and how their form and meaning have changed over time. By an extension, the term "etymology (of a word)" means the origin of a particular word. When "etymology" is used in fungi descriptions it is intended to bring clarity regarding the meaning of the name or why the name of the species was chosen.

Euagarics (Synonymous with Agaricales): Fungi belonging to the subdivision Basidiomycota. This definition may undergo revision.

Eukaryote: Fungi are eukaryotes (ie they have a true nucleus). A eukaryote is an organism whose cells contain complex structures enclosed within membranes. The defining membrane-bound structure that sets eukaryotic cells apart from prokaryotic cells is the nucleus, or nuclear envelope, within which the

genetic material is carried.

Eumycota: True fungi; eukaryotic, heterotrophic, walled organisms distinguished from the Myxomycota (fungus-like slime molds). Eumycota comprises the subdivisions Mastigomycotina; Zygomycotina; Ascomycotina; Basidiomycotina; Deuteromycotina (imperfect fungi).

Eusporium: The inner set of firm and resistant layers of the spore wall, consisting of the episporium and the endosporium.

Evanescent: Soon disappearing, fleeting - sometimes in relation to a particular feature of the mushroom.

Evolutionary Isolation: Isolation means that organisms of the same species are separated, and happens when there is something between the organisms that they can't cross. Organisms become isolated as a result of environmental change. The cause of isolation can be gradual, like when mountains or deserts form, or continents split apart. It can also be quick, such as organisms being blown to different places by a storm or tsunami (tidal waves). When organisms become isolated the two groups are also not able to reproduce together, so variations and mutations that occur in one group are not necessarily found in the other group. The longer the groups are isolated, the more different they are. They eventually become different species. Moreover, if there is a change in the environment of one group it does not necessarily occur in the environment of the other. So they will evolve and adapt differently.

Evolutionary Plasticity (Phenotypic Plasticity): Plasticity is usually thought to be an evolutionary adaptation to environmental variation that is reasonably predictable and occurs within the lifespan of an individual organism, as it allows individuals to ‘fit’ their phenotype to different environments. If the optimal phenotype in a given environment changes with environmental conditions, then the ability of individuals to express different traits should be advantageous and thus selected for. Hence, phenotypic plasticity can evolve if Darwinian fitness is increased by changing phenotype. However, the fitness benefits of plasticity can be limited by the energetic costs of plastic responses (e.g. synthesizing new proteins, adjusting expression ratio of isozyme variants, maintaining sensory machinery to detect changes) as well as the predictability and reliability of environmental cues (see Beneficial acclimation hypothesis).

ex: Latin for "out of, or from." Sometimes used when an author has derived worked from another author.

Excentrically Stipitate: Possessing a stipe that is not centrally connected to the pileus.

Exo-: On the outside (as in on the outside of a cell or part of a structure area). External.

Exsiccata: An intentionally dried section of material or dried specimens (for microscopy or herbarium storage).

Excl: Abbreviation for excluded.

Exemplar Taxa: Serving as a typical example or excellent model.

Exocytosis: The durable process by which a cell directs the contents of secretory vesicles out of the cell

membrane and into the extracellular space. These membrane-bound vesicles contain soluble proteins to be secreted to the extracellular environment, as well as membrane proteins and lipids that are sent to become components of the cell membrane.

Exon: Any nucleotide sequence encoded by a gene that remains present within the final mature RNA product of that gene after introns have been removed by RNA splicing.

Exosporium: Reference to the spore wall. A layer of the basidiospore wall between perisporium and episporium, frequently responsible for the ornamentation of spores.

Exudates: Something exuded (outputted, emitted, oozed, or sweated) by a living organism such as tree roots and certain yeasts. In certain mycorrhizal mushrooms being cultured on agar it is necessary to use exudates in order to initiate spore germination.

f.: Form. A particular phenotype known within a species.

Fabiform: Broad bean-shaped.

Face View of Spores: Of spores, when the basidium with attached spores is viewed from the side, the spores directly above and in the center are being viewed in face view and the ones at the sides are in profile view, when not attached to basidium the shape that is wider will generally be the face view if there is a difference. Compare *Face View* to *Side View* and *Profile View*.

Falcate: Sickle-shaped.

Falciform: Scythe-shaped.

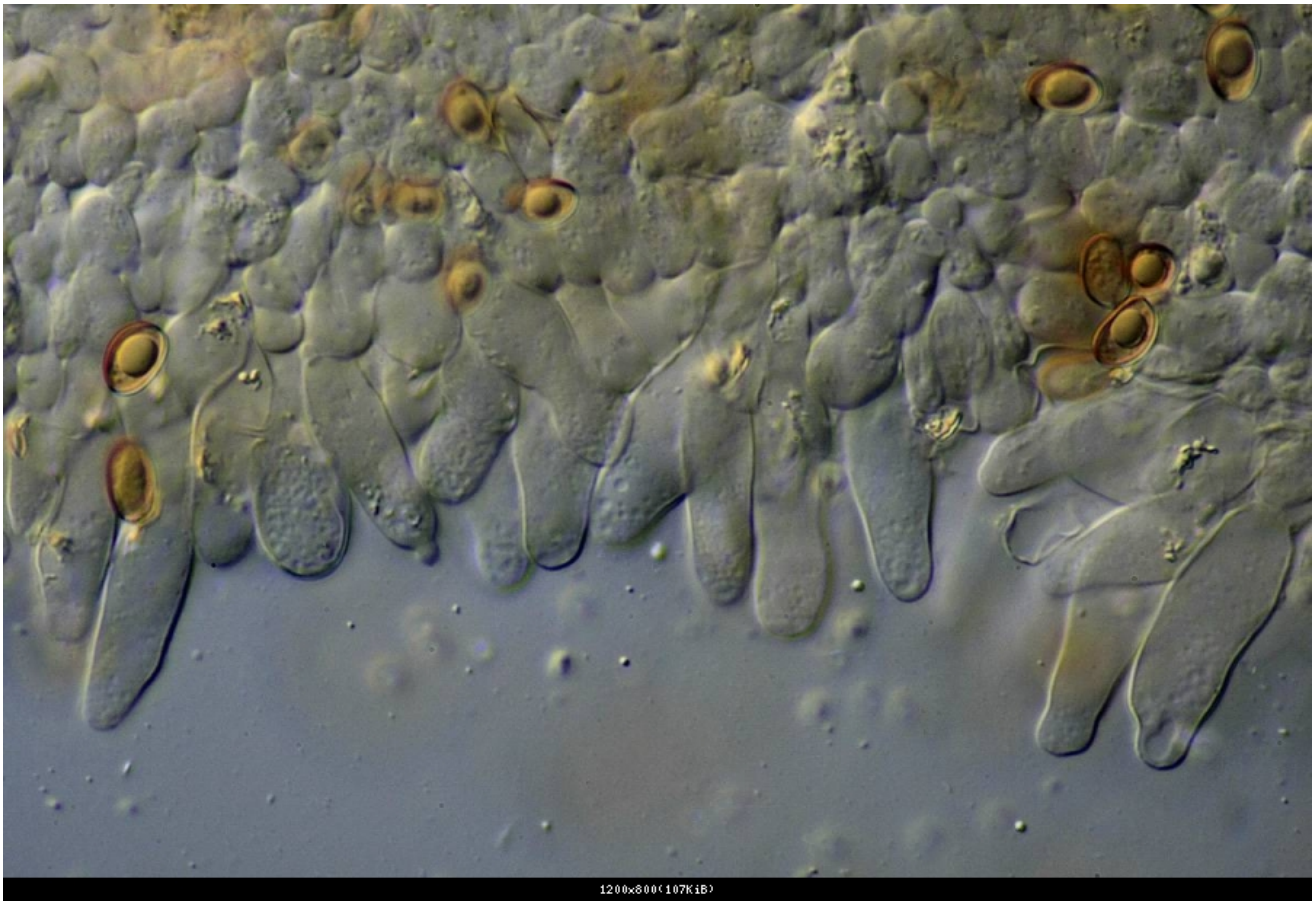
Falsely Echinulate: Of spores, appearing ornamented with fine spines in optical section but actually with smooth outline.

Family: In biological classification, family (Latin: familia) is a taxonomic rank. Other well-known ranks are life, domain, kingdom, phylum, class, order, genus, and species, with family fitting between order and genus. As for the other well-known ranks, there is the option of an immediately lower rank, indicated by the prefix sub-: subfamily (Latin: subfamilia). a taxonomic unit, a taxon, in that rank. In that case the plural is families (Latin familiae). Example: Walnuts and hickories belong to Juglandaceae, the walnut family.
What does and does not belong to each family is determined by a taxonomist. Similarly for the question if a particular family should be recognized at all. Often there is no exact agreement, with different taxonomists each taking a different position. There are no hard rules that a taxonomist needs to follow in describing or recognizing a family. Some taxa are accepted almost universally, while others are recognised only rarely.

Farinaceous (Farinaceous odor or taste): Often compared to the odor of cucumbers, watermelon rind, or an old grain mill. Common in many mushrooms, including *Polyporus squamosus, Agrocybe praecox, Mycena galericulata, Tricholoma sejunctum, Clitopilus prunulus,* and *Entoloma abortivum*. Some mycologists (Smith et al., 1979; Moser, 1983) subdivide "farinaceous" into three odor groups: Strictly

farinaceous, cucumber/farinaceous, and rancid-oily-fishy/farinaceous. The cucumber/farinaceous sub-odor has been upheld by chemical research (Wood et al., 1994) as a valid distinction, and the chemical named Trans-2-Nonenal has been identified as being responsible for it.

Fasciculate: Arranged in a fascicle or fascicles (close clusters).



Above: A fascicle (close cluster) of cheilocystidia cells from the species *Inocybe fastigiata* courtesy Linas Kudzma

Fertile: Lamella edge composed of basidia only.

FeSO (Synonymous in Mycology with (FeSO4): Chemical used to test macroscopic color change(s) on stipe, pileus, or lamella. (Other synonyms: Iron(II) sulfate, Iron sulfate, iron(II) sulphate, and ferrous sulfate).

Fiabelliform: Fan-shaped.

Fibril (Fibrils): Relatively small extensions or hair-like projections, usually in reference to extensions emanating from the stipe.

Fibrillose: Covered with hair-like appendages.

Fibrillose-Membranaceous Annulus: Any annulus possessing hair-like appendages and resembling a membrane (like a membrane; thin and flexible, or pliant).

Fibrous: Consisting of, containing, or resembling fibres.

Fibulate (Fibulate Hyphae): "Fibulate hyphae" mean "clamped hyphae." The septa are not simple but with clamps (fibulae).

Filamentous: 1. Composed of hyphae (threadlike cells). 2. Hyphae which form thread-like, wire-like forms. 3. A slender, thread-like chain of cells.

Filamentous Hyphae: Thin in diameter; resembling a thread.

Filiform Cystidia: 1. Very long and narrowly-cylindrical cystidia. 2. Relatively narrow, thread-like cystidia.

Fimbriate: Lamella edge with regular hair-like projections.

Fimicolous: Of or pertaining to an organism that lives on or in animal dung.

Fistulose: Stipe is hollow.

Fixative: A substance used for the preservation of tissue or cell specimens such as 20% Acetic Acid combined with 80% Ethanol. The most commonly used fixative in general histology is *Formaldehyde*.

Flabelliform: Shaped like a fan.

Flavo-Melleous (Flavo Melleous): Honey-yellow.

Flesh: The tissue of cap or stem, not including the surface.

Flexuose: 1. Full of bends. 2. Cystidia that are cylindrical but full of bends.

Flexuous: Full of bends or curves; winding

Floccose (Floccus, Flocculose): Covered in wooly tufts; having tufts of soft woolly hairs. Possessin fine, easily removed cottony or woolly tufts; finely woolly or cottony.

Flora: Flora is the plant life occurring in a particular region or time, generally the naturally occurring or indigenous—native plant life. The corresponding term for animal life is fauna. Flora, fauna and other forms of life such as fungi are collectively referred to as biota. Bacterial organisms, algae, and other organisms - including fungi - are sometimes referred to as flora.

Fluorescent Marker: Fluorescent labelling is the process of covalently attaching a fluorophore to another molecule, such as a protein or nucleic acid. This is generally accomplished using a reactive derivative of the fluorophore that selectively binds to a functional group contained in the target molecule. The most commonly labelled molecules are antibodies, proteins, amino acids and peptides which are then used as specific probes for detection of a particular target. Fluorescent labels are generally used for detection of a protein or other labeled molecule via a fluorescence microscope, flow cytometer or some other fluorescence reading instrument. These can be useful in localization of a target within a cell, flow

cytometry (FACS) analysis, western blot assays, and other immunoanalytical methods.

Focus Stacking: Taking multiple (sometimes six or more - even up to 30 or more) photos of the same area with different parts in focus - then combining all of these images using a program that helps retain the sharp, crisp aspects of each photo - for a combined single image with every aspect in focus. This feature resolves Depth of Field differences between each photo that otherwise the camera (and/or objectives) could not capture in one image.

Forked Cystidia (Especially *Forked Cheilocystidia*): Instead of one singular pointed-shape there are two emerging from the identical cell.

Forma specialis (Pl., Formae speciales): The taxonomic grouping allowed by the ICN that is applied to a parasite (most frequently a fungus) which is adapted to a specific host (there being minimal or no morphological differences). This classification may be applied by authors who do not feel that a subspecies or variety name is appropriate. An example species is *Puccinia graminis*.

Fr. (Fr.): Described by Elias Magnus Fries.

Elias Magnus Fries Courtesy Wikimedia Commons

Free (Free Gills): This term is used to refer to gills and their position in relation to the stipe. If free, the gills don't reach (touch) the stem. Instead, they turn up into the cap. Tip: The stem will often come off easily without damaging the mushroom.

Free Hand Sections: Sections made by hand instead of a machine or microtome.

Free-Standing Lamellulae (Synonymous with Short Gills):

Freeze Substitution (Freeze-Substitution): Freeze-substitution is based on rapid freezing of tissues followed by solution ("substitution") of ice at temperatures well below O°C - for the gentle fixation and dehydration of tissue. Freeze substitution is a process for low temperature dehydration and fixation of rapidly frozen cells that usually takes days to complete.

Friesian System: The 18th century “Friesian system” divided macrofungi according to physical, macroscopic morphology. It was particularly based on the form of the hymenophore (spore-producing structures or gills).

Fringed: With irregular appendages.

Fructiferous: Producing fruit or fruit-bearing fungi.

Fugacious: Showing visibility for only a a short time. See H.R. Hesler's *North American Species of Gymnopilus Gymnopilus* (subgenus Gymnopilus).

Fulvous Scales: Scales that possess a dull brownish-yellow color.

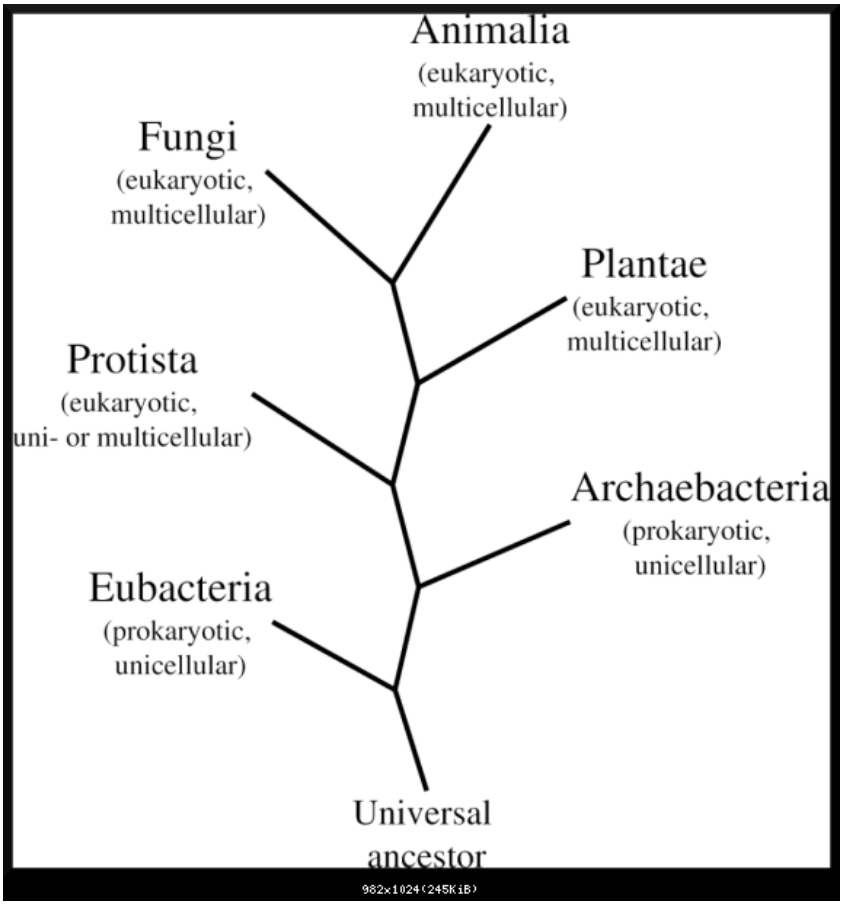
Fundamental Tissue: 1. Inflated, multiseptate, thick-walled (more or less sclerified) hyphae of the basidiocarp. Skeletal hyphae and fusiform skeletals sometimes included. Found in any part of a young basidiocarp in agarics. 2. Fundamental Tissue is composed of thick-walled, skeletal, binding hyphae.

Fungicolous Fungi: Fungi species that are consistently associated with other fungi.

Fungivores: Fungivory or mycophagy is the process of organisms consuming fungi. Many different organisms have been recorded to gain their energy from consuming fungi, including birds, mammals, insects, plants, amoeba, gastropods, nematodes and bacteria. Some of these, which only eat fungi are called fungivores whereas others eat fungi as only part of their diet, being omnivores.

Fungoid: Resembling a fungus or fungi, a fungoid growth.

Fungus (Pl., Fungi): A fungus is a member of a large group of *eukaryotic* organisms that includes microorganisms such as yeasts and molds (British English: moulds), as well as the more familiar mushrooms. These organisms are classified as a kingdom, Fungi, which is separate from plants, animals, and bacteria. One major difference is that fungal cells have cell walls that contain chitin, unlike the cell walls of plants, which contain cellulose. These and other differences show that the fungi form a single group of related organisms, named the *Eumycota* (true fungi or Eumycetes), that share a common ancestor (a monophyletic group). This fungal group is distinct from the structurally similar myxomycetes (slime molds) and oomycetes (water molds). The discipline of biology devoted to the study of fungi is known as mycology, which is often regarded as a branch of botany, even though genetic studies have shown that fungi are more closely related to animals than to plants. (Fungi is most often pronounced fun-jigh, (jigh rythmes with high), although some mycologists pronounce it fung-ghee or fun-guy.



Above: The current classification system of six kingdoms known in the study of life (courtesy Wikimedia Commons). Note that Fungi, one of the six kingdoms, are more related to humans than plants.

Furcate: Forking; forked or branched irregularly.

Furfural: A colorless, sweet-smelling, mobile liquid, C_4H_3OCHO, made from corncobs and used in the synthesis of furan, as a solvent for nitrocellulose, and as a fungicide and weed killer. A 0.01% aqueous solution is sometimes added (prior to pouring) agar for streaking spores that resist germination attempts.

Ferruginous: 1. Reddish brown or rust color. 2. Containing iron oxides or rust.

Fuschinophile Hyphae: Hyphae that react with *fuschin*.

Fusiform: Spindle-shaped; rounded and tapering from the middle toward each end, as some roots.

Fusiform-Lanceolate: Spindle-shaped and lance shaped; much longer than wide, with the widest part lower than the middle and a pointed apex.

Fusoid: Somewhat spindle-shaped.

Fusoid-Ampullaceous: Used in reference to a somewhat common cystidia shape in which there is both a fusoid (slightly spindle-shaped) and an ampullaceous (like an ampulla; bottle-shaped) resemblance. (View cheilocystidia from *Psilocybe quebecensis* for comparison).

Below: Fusoid-ampullaceous cheilocystidia with extended neck from the Quebec mushroom *Psilocybe quebecensis* courtesy Alan Rockefeller

Fusoid-Ventricose: Of cystidium, tapered toward both ends but distinctly enlarged in the middle.

Gamete (Pl. Gametes): In gilled mushrooms the gamete is the basidiospore (or simply put, the spores).

Gas Chromatography: Gas chromatography (GC), is a common type of chromatography used in analytical chemistry for separating and analyzing compounds that can be vaporized without decomposition. Typical uses of GC include testing the purity of a particular substance, or separating the different components of a mixture (the relative amounts of such components can also be determined).

Gastroid: Gastroid fungi include larger fungi - basidiomycetes - with underground, semi-underground or less often emergent fruit bodies, completely enclosed hymenium, and without a distinct cap or stipitate columella. Some species are closely related to gilled fungi.

Gelatinized Cells (on the cap surface): The cells on the surface of the cap sometimes appear gelatinized, vague, and out of focus. When you are sure that they really aren't out of focus, you may be looking at the microscopic evidence of a viscid/slimy or once-viscid cap.

Gelatinous: Having the nature of or resembling jelly, especially in consistency; jellylike. Pertaining to, containing, or consisting of gelatin.

Gelatinous Separable Pellicle: Having a clear, gel-like layer on-top of the pileus that can be pinched and carefully separated.

Above: A freshly harvested specimen has its pileus broken and peeled slowly, showing its gelatinous separable pellicle

gen.: Genus.

gen. et nom nov.: Genus and name new.

gen. et sp. nov.: Abbreviation for *genus et species nova*, meaning new genus and species.

gen. nov. (genus novum): New genus.

Gene: The basic physical unit of heredity; a linear sequence of nucleotides along a segment of DNA that provides the coded instructions for synthesis of RNA, which, when translated into protein, leads to the expression of hereditary character.

Gene Expression: Gene expression is the process by which information from a gene is used in the synthesis of a functional gene product. These products are often proteins, but in non-protein coding genes such as ribosomal RNA (rRNA), transfer RNA (tRNA) or small nuclear RNA (snRNA) genes, the product is a functional RNA. The process of gene expression is used by all known life - eukaryotes (including multicellular organisms), prokaryotes (bacteria and archaea), possibly induced by viruses - to generate the macromolecular machinery for life. Several steps in the gene expression process may be modulated, including the transcription, RNA splicing, translation, and post-translational modification of a protein. Gene regulation gives the cell control over structure and function, and is the basis for cellular differentiation, morphogenesis and the versatility and adaptability of any organism. Gene regulation may also serve as a substrate for evolutionary change, since control of the timing, location, and amount of

gene expression can have a profound effect on the functions (actions) of the gene in a cell or in a multicellular organism.

Gene Regulation: Regulation of gene expression includes a wide range of mechanisms that are used by cells to increase or decrease the production of specific gene products (protein or RNA), and is informally termed gene regulation. Sophisticated programs of gene expression are widely used in biology, for example to trigger developmental pathways, respond to environmental stimuli, or adapt to new food sources. Virtually any step of gene expression can be modulated, from transcriptional initiation, to RNA processing, and to the post-translational modification of a protein. In genetics, gene expression is the most fundamental level at which the genotype gives rise to the phenotype. The genetic code stored in DNA is "interpreted" by gene expression, and the properties of the expression give rise to the organism's phenotype. Such phenotypes are often expressed by the synthesis of proteins that control the organism's shape, or that act as enzymes catalysing specific metabolic pathways characterising the organism.

Gene Genealogy (Genetic Genealogy): Genetic genealogy is the application of genetics to traditional genealogy. Genetic genealogy involves the use of genealogical DNA testing to determine the level of genetic relationship between individuals.

Gene Locus: The specific location of a gene or DNA sequence on a chromosome. A variant of the similar DNA sequence at a given locus is called an allele. The ordered list of loci known for a particular genome is called a genetic map. Gene mapping is the procession of determining the locus for a particular biological trait.

Gene Mapping (Genome Mapping): The creation of a genetic map assigning DNA fragments to chromosomes.

Gene Marker (Genetic Marker): A genetic marker is a gene or DNA sequence with a known location on a chromosome that can be used to identify individuals or species.

Genera: Plural for genus. Two or more genuses. Pronounced gen-rrr-uh.

Generative Hyphae: Thin-walled, septate, undifferentiated or sometimes slightly thickened hyphae with continuous protoplast which stains intensely with cotton blue.

Genet (Synonymous with Clonal Colony): A clonal colony or genet is a group of genetically identical individuals, such as plants, fungi, or bacteria, that have grown in a given location, all originating vegetatively, not sexually, from a single ancestor. In fungi, "individuals" typically refers to the visible fruiting bodies or mushrooms that develop from a common mycelium which, although spread over a large area, is otherwise hidden in the soil.

Genetic Divergence: The process in which two or more populations of an ancestral species accumulate independent genetic changes (mutations) through time, often after the populations have become reproductively isolated for some period of time. In some cases, subpopulations living in ecologically distinct peripheral environments can exhibit genetic divergence from the remainder of a population, especially where the range of a population is very large

Genetic Map (Synonymous with Gene Map or Genetic Linkage): The tendency of genes that are located proximal to each other on a chromosome to be inherited together during meiosis. Genes whose loci are nearer to each other are less likely to be separated onto different chromatids during chromosomal crossover, and are therefore said to be genetically linked.

Genetic Marker: A gene or DNA sequence with a known location on a chromosome that can be used to identify individuals or species. It can be described as a variation (which may arise due to mutation or alteration in the genomic loci) that can be observed. A genetic marker may be a short DNA sequence, such as a sequence surrounding a single base-pair change (single nucleotide polymorphism, SNP), or a long one, like minisatellites.

Genome: In modern molecular biology and genetics, the genome is the entirety of an organism's hereditary information. It is encoded either in DNA or in RNA. The genome includes both the genes and the non-coding sequences of the DNA/RNA.

Genotype (Pl., Genotypes): 1. The genetic makeup of an organism or group of organisms with reference to a single trait, set of traits, or an entire complex of traits. 2. The sum total of genes transmitted from parent to offspring.

Genus: A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.

Geographical Distribution: 1. The natural occurrence of an organism in particular areas. 2. The occurrence of an organism in particular areas.

Germination: Germination refers to the emergence of cells from resting spores and the growth of sporeling hyphae or thalli from spores in fungi. With many mushroom species, germination begins in the dimpled depression on the spore. The process initially looks like a seed sprouting.

Germ Pore (in reference to a spore): A germ pore is a small hole (or pore) in the outer wall of a fungal spore through which the germ tube or hypha exits - upon germination. It can also be referred to as "apical germ pore," which means the identical thing in mycology. The germ pore is a thin spot in the wall through which the spore may germinate. This pore may be oblique or centered with respect to the spore axis.

Germ slit (in reference to a spore): If the cell wall of an individual spore is divided from one end to the other, this is called a germ slit (meaning there's a line travelling from one pore end to another pore end). Alternatively a slit does not have to reach the full length of the spore.

Germ tube: When a spore begins to create hypha it is sometimes initially referred to as a germ tube.

Gestalt: Essence or shape of a mushroom's complete form.

Gibbous: Refers to nodulose-spored condition of basidiospores.

Gill Arrangement: The appearance and order of the gills and how they are described (for

instance *close*, *spaced out*, etc)

Gill Cross Section: A gill cross section is a special area of examination removed from a basidiomycete. Here are the steps to perform a gill cross section: 1. Take a freshly harvested mushroom and gently remove the stem with thumbnail and forefinger 2. Set the cap down (gill-side down as if taking a spore print) on piece of clean paper 3. Using a fresh razor blade, make a thin, top-to-bottom slice and discard this first slice (sometimes you will have to do this two, three, even four times depending on the cap shape so you can actually get to the gills) 4. Once you see that the gills are perfectly within super-thin-slice reach, make the actual incision to obtain the gill cross section 5. Lay this gill cross section down flat (on a microscope slide) on its side, mount in 3% KOH, and place a slide cover over it without crushing it and examine under the microscope.

Gill Plane: This term can be used to describe any flat surface of a gill (section) and there are a few types: Perradial, paracial, parahymenial. Synonyms and other section types also exist.

Gill Trama: The inside tissue of a gill. The hymenophoral trama of gilled basidiocarps.

Gills (Synonymous with Lamellae): The many platelike or bladelike structures attached to the underside of the cap in some mushrooms, representing an ingenious reproductive strategy.

Glabrous: Pileus and stipe surfaces are bald.

Glandular Dots: Glandular dots appear on the stems of some mushrooms. The dots are usually very small and result from clusters of pigmented, inflated cells on the stem surface. Many species have whitish or pale glandular dots that do not darken and become conspicuous until maturity, or when the mushroom is dried. Glandular dots result from clustered caulocystidia (inflated cells) on the stem surface.

Globose (Globular): 1. Having the shape of a globe; globelike. 2. Spore Q=0.95-1.05 3. Cystidia Q=1.0-1.5.

Globose-Rhombi: Shaped both like a globe and an oblique-angled equilateral parallelogram.

Globular-Type Pileipellis Cells: A pileipellis consisting of cells shaped like globes (round).

Gloeocystidium (Pl. Gloeocystidia): Thin-walled cystidia with refractive, frequently granular contents. A cystidia which easily stains with a chemical reagent or has visible or granular contents. An exudative sterile cell with oily or resinous contents.

Gloeohyphae (Gloeohypha, Gloeoplerous): Hyphae which show an oily or granular appearance under the microscope. This appearance is known to be produced due to a high refractive index in the tissue.

Gloeovessels (Gloeo-Vessels): Those hyphae, only aseptate, connected to and possessing similar chemical characters as gloeocystidia. Vessel-like elements attached to gloeocystidia projected into the trama and staining deep blue in cresyl blue.

Glutin-Supporting Hyphae (Gluten Supporting Hyphae, Gluten-Supporting Hyphae):

Glutinous: Like glue in texture; sticky.

Glutinous Veil Remnants: Remaining veil material with a glue-like, sticky feature.

Golgi Apparatus: The Golgi apparatus, also known as the Golgi complex, Golgi body, or simply the Golgi, is an organelle found in most eukaryotic cells. Part of the cellular endomembrane system, the Golgi apparatus packages proteins inside the cell before they are sent to their destination; it is particularly important in the processing of proteins for secretion. Due to its large size, the Golgi apparatus was one of the first organelles to be discovered and observed in detail. Found within the cytoplasm of both plant and animal cells, the Golgi is composed of stacks of membrane-bound structures known as cisternae (singular: cisterna).

Graniform: Shaped like grains of corn.

Granular: Resembling or consisting of small grains or particles. Resembling sugar granules. Found in dense conidia on surface hyphae cells.

Granulose: Pileus or stipe surface is covered with or composed of minute grains.

Gregarious: Growing in a group but not clumped or joined - a bit spaced out. Growing in groups that are close together but not densely clustered.

Grooved: Spores which have at least two folds which form close enough together to form a thin, deep line-like mid-way area.

Group (Taxonomic Group(s)): A taxonomic group (e.g. "*Amanita pantherina* group") can refer to a species, genus, genera, etc. The phrase is usually used as a generalized category in order to further study a species of fungi that demonstrates a confusing variance in appearance, habitat, or other traits, without assuming the true variance of a species and simply labelling collections with a certain species name.

Guaiac: Macrochemical prepared with 95% elthyl alcohol satured with gum guaiac and used to test for presence of phenol-oxidase enzymes in mycelium.

Guttiform: Having the shape of a drop. Drop-like in form.

Guttulate: Containing one or several oil droplets (guttules) inside a cell; usually referring to the cell lumina of a non-septate spore.

Guttule: Droplet.

Guzmán: Described by Dr. Gastón Guzmán.

Above: Image courtesy Wikimedia Commons

Gymnocarpous: Having the hymenium uncovered on the surface of the thallus or fruiting body.

Gymnocarpy: A type of development of the basidiocarp in which the hymenium is exposed from initiation until maturity.

Habitat: A habitat is an ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilized by) a species population

Hair (Synonymous with Pilocystidium but not Pileocystidium depending on the author): Fibrils or mycelial strands resembling hairs.

Hallucinogenic (Hallucinogen, Hallucinate): 1. Producing hallucinations. 2. A substance that is a hallucinogen. 3. Hallucinogens are a general group of pharmacological agents that can be divided into three broad categories: psychedelics, dissociatives, and deliriants. These classes of psychoactive drugs have in common that they can cause subjective changes in perception, thought, emotion and consciousness. Unlike other psychoactive drugs, such as stimulants and opioids, these drugs do not merely amplify familiar states of mind, but rather induce experiences that are qualitatively different from those of ordinary consciousness. These experiences are often compared to non-ordinary forms of consciousness such as trance, meditation, dreams, or insanity. Note that some prefer the term "neurotropic" instead of hallucinogenic to more accurately define the causative effects of certain fungi (i.e. species in the genus Psilocybe, etc).

Hallucinogenic Mushrooms: The name commonly given to psychoactive fungi, containing hallucinogenic compounds, most commonly psilocybin and psilocin. At low doses, hallucinogenic drugs have as their

primary effects perceptual distortions and alterations of thought, or mood, with the presence of lucid awareness and minimal effects on memory and orientation. Note that some prefer the term "neurotropic" instead of hallucinogenic to more accurately define the causative effects of certain fungi (i.e. species in the genus Psilocybe, etc).

Halocystidia: Thin-walled capitate hymenocystidia, capitate apex surrounded by with large oil drop, sometimes reported to be contained within a cellular structure.

Hand Lens: A hand-held magnfication system similar to a magnifying glass, but oftentimes capable of multiple magnfications and smaller. This device can be used before and during the sectioning process when preparing a slide for microscopy. It can also be used to assist in the study of tissue areas of both basidiocarps and myceliums while in the field to. In this regard, it can be used to study color and patterns more closely.

Below: A 5x and 10x hand lens is a highly valuable tool to the mycologist during field identification and lab microscopy

Haploid: Haploid is the term used when a cell has only one set of chromosomes (ie half or 50 percent of the needed chromosome data). A normal eukaryote organism is composed of diploid cells, one set of chromosomes from each parent (versus haploid which implies the need for two cells, each with 50 percent of the chromosome data necessary to be "whole," to merge together in order to contain a complete set of chromosome information. (Compare to *mating types*).

Haploid Nucleus: A nucleus possessing only half the normal somatic number of chromosomes.

Haustoria: A haustorium (plural haustoria) is the appendage or portion of a parasitic fungus (the hyphal tip) or of the root of a parasitic plant (such as the broomrape family or mistletoe) that penetrates the host's tissue and draws nutrients from it. Haustoria do not penetrate the host's cell membranes. Fungi in all major divisions form haustoria. Haustoria take several forms. Generally, on penetration, the fungus increases the surface area in contact with host plasma membrane releasing enzymes that break down the cell wall, enabling greater potential movement of organic carbon from host to fungus. Thus, an insect hosting a parasitic fungus such as Cordyceps may look as though it is being "eaten from the inside out" as the haustoria expand inside of it.

Hegemonic (Synonymous with Spermatic): An aroma arising from the sporocarp that is decidedly similar to that of human seed (semen).

Heim (R. Heim): The standard author abbreviation R. Heim is used to indicate Roger Heim as the author when citing a mycological name.

Above: Roger Heim 1900-1979

Heliotropes (Heliotropic): Sun-lovers. Growing towards the direction of the sun or light. Heliotropism is the diurnal motion or seasonal motion of plant parts (flowers or leaves) in response to the direction of the sun. Some - not many - mushrooms are heliotropic.

Hemiangiocarpus (Synonymous with Hemiangiocarpous, Hemi-Angiocarpous, and Hemiangiocarpic): Initially with an enclosed development of the sporocarp, but opening before maturity; during the ontogeny usually enclosed by a proper exciple and a layer of thallus hyphae. Partly angiocarpous. The gill

tissue is concealed by a veil (or otherwise) for a portion of the growth cycle, but eventually the gills become exposed. A pseudoexciple. This feature is characteristic for many lichenized ascomycetes, including *Peltigeraceae* and *Stictaceae*.

Hemicellulose: Any of several heteropolymers (matrix polysaccharides), such as arabinoxylans, present along with cellulose in almost all plant cell walls. While cellulose is crystalline, strong, and resistant to hydrolysis, hemicellulose has a random, amorphous structure with little strength. It is easily hydrolyzed by dilute acid or base as well as myriad hemicellulase enzymes.

Hemispherical: Pileus with shape of half a sphere.

Hemocytometer: The hemocytometer is a device used to count cells. It was originally designed for the counting of blood cells. The hemocytometer was invented by Louis-Charles Malassez and consists of a thick glass microscope slide with a rectangular indentation that creates a chamber. This chamber is engraved with a laser-etched grid of perpendicular lines. The device is carefully crafted so that the area bounded by the lines is known, and the depth of the chamber is also known. It is therefore possible to count the number of cells or particles in a specific volume of fluid, and thereby calculate the concentration of cells in the fluid overall.

Hemyamyloid: A hemyamyloid reaction is a red reaction with Lugol’s reagent.

Hesler: The name Hesler is used to indicate a fungal name described by Dr. L.R. Hesler.

Above: Dr. L.R. Hesler, courtesy University of Tennessee Special Collections

Heterogenous: 1. Consisting of dissimilar elements or parts; not homogeneous. 2. not of the same kind or type.

Heterogeneity: Consisting of dissimilar elements or parts; not homogeneous.

Heterokaryotic: Cells where two or more genetically different nuclei share one common cytoplasm. It is the antonym of homokaryotic. This is the stage after plasmogamy, the fusion of the cytoplasm, and before karyogamy, the fusion of the nuclei. It is neither 1n nor 2n. It is in the sexual reproductive cycle of fungal organisms.

Heteromerous: Trama found in the Russulaceae. Tissue consisting of hyphae and "nests" of spherocysts.

Heteromerous Trama: Contains rounded elements called sphaerocysts as well as filamentous hyphae.

Heteromorphus: A type of gill edge in which the cheilocystidia have different shapes and sizes than the pleurocystidia.

Heterothallic: Heterothallic species have sexes that reside in different individuals. The term is applied particularly to distinguish heterothallic fungi, which require two compatible partners to produce sexual spores, from homothallic ones, which are capable of sexual reproduction from a single organism.

Heterotroph: Fungi do not use the sun to feed themselves (like plants). Nor do they take in CO2 like plants do. Instead, they feed on organic materials (wood chips, soil, etc) and process these materials for food and energy. A heterotroph is an organism that is unable to synthesize its own organic carbon-based compounds from inorganic sources, hence, feeds on organic matter produced by, or available in, other organisms. All gilled mushrooms (and all fungi currently described) are heterotrophs.

Heterotrophic Spore (Synonymous with Heterotropic Spore): A spore which is borne obliquely on the sterigma. This type of attachment facilitates spore discharge. The spores are asymmetrical.

Heterozygous: Having the two alleles at corresponding loci on homologous chromosomes different for one or more loci.

Hexagonal: Having six sides. Spores that have six angles.

HI: PAUP Homoplasy Index (HI).

Hilum (Pl., Hila): A scar on spore created by detachment. There are two types of hilum: Nodulose and Open-pore. The features of these types is best seen using a SEM (Scanning Electron Microscope) at a college or university.

Hilar Appendage (Hilar Appendix): Reference to spores that have a short extension/part at the basal end of the spore, by which it was attached to sterigma. The Hilar Appendix is the specialized part of the adaxial wall of the spore which is the site of formation of the liquid or gaseous droplet associated with extremely violent spore discharge (See "Buller's Drop").

Hilar Droplet: See "Buller's Drop".

Hilar Spot (Synonymous with Plage, Suprahilar Depression): A small depression found near the hilar appendix. Amyloid in many Russula sp.; non-amyloid and poorly colored in Melanoleuca sp.; ornamented in some collections of Coprinus micaceus; rough in rough spores of Galerina laevis; smooth in the roughened spores of Galerina hypnorum.

Hilum: The actual spore surface that makes contact with the sterigmata.

Hirsute: Pileus or stipe covered with hairs that are rather long and course. More course than pubescent and less course than hispid.

Hispid: Pileus or stipe surface covered with hairs (or bristles) that are long or short, erect, and stiff.

Hispid-Squarrose: Stiff, erect scales.

Hispidulous: Minutely hispid.

Histology: Histology is the study of the microscopic anatomy of cells and tissues of plants and animals. Note that tissues from plants, fungi, and microorganisms can also be examined histologically, but their structure is very different from animal tissues.

Hollow (Hollow Stipe): Stipe possessing no solid or "stuffed" hyphae, and is instead hollowed out.

Holobasidium: A single-celled basidium. Typical of most gilled mushrooms.

Holomorph: The whole fungus, including anamorphs and teleomorph.

Holotype (Holotype Collection, Type Collection): A holotype is a single physical example (or illustration) of an organism, known to have been used when the species (or lower-ranked taxon) was formally described. It is either the single such physical example (or illustration) or one of several such, but explicitly designated as the holotype. (See also *Isotype*).

Holotype Locality: The area of origin from which the holotype was found and collected.

Homobasidiomycetes: Homobasidiomycetes comprise approximately 16,000 described species. This number reflects 98% of the described species in the Hymenomycetes (Kirk et al. 2001). Homobasidiomycetes produce mushrooms. Other Fungi produce macroscopic fruiting bodies as well, but the diversity of forms in the Homobasidiomycetes is without parallel. Fruiting bodies of Homobasidiomycetes range from millimeter-scale cyphelloid forms (resembling tiny cups), to the giant polypores *Rigidoporus ulmarius* (up to 316 kg) and *Bridgeoporus nobilissimus* (up to 130 kg). Homobasidiomycetes include not only the largest fruiting bodies in Fungi, but perhaps the largest and oldest individuals in any group of organisms. Clones of *Armillaria gallica*, produce average-sized mushrooms, but their mycelial networks are estimated to cover up to 15 hectares and an age of 1500 years (Smith et al. 1992).

Homoiomerous: Composed of a single kind of hyphae strand, applied to the hymenophoral trama and typical of most agarics except the Russulaceae.

Homoiomerous Trama: Trama with cells that form filamentous hyphae.

Homokaryon (Homokaryotic): A hyphal cell, mycelium, organism, or spore in which all the nuclei are genetically identical. Genetically identical multiple nuclei in a common cytoplasm, usually resulting from fusion of two cells from the same species.

Homology: Homology is evaluated strictly in an evolutionary context. That is, organs in two species are homologous only if the same structure was present in their last common ancestor.

Homologous: Traits of a species that are due to descent from a common ancestor.

Homomorphus: A gill in which the hymenium lining the face is the same as that lining the margin.

Homothallic: Homothallic refers to the possession, within a single organism, of the resources to reproduce sexually. Having male and female reproductive structures on the same thallus. The opposite sexual functions are performed by different cells of a single mycelium. It can be contrasted to heterothallic. It is often used to categorize fungi. In yeast, heterothallic cells have mating types a and α. An experienced mother cell (one that has divided at least once) will switch mating type every cell division cycle because of the HO allele.

Homonym: A name spelled exactly like an earlier valid name (regardless of whether this is legitimate or illegitimate), or confusingly closely spelled. You can and should use *MycoBank* and *Index of Fungi* or *Index Fungorum* to check for earlier potential fungal homonyms and also Index Kewensis and other sources via the *International Plant Names Index or Tropicos* or *AlgaeBase* for many botanical names. Check *Index Nominum Genericorum* to ensure the generic name in which you are publishing your species, is uniquely fungal. If there are other valid 'botanical' homonyms at the generic rank, consider that there is the potential for you to create a later homonym at the species rank to a species in that other genus. You should check *Genbank* and also the WWW for any such uses regardless of whether they are valid or legitimate.

Homoplasious: Characters that have converged to seem similar.

Homoplastic (Homoplasy): 1. Similar in form and structure, but not in origin. 2. Of, relating to, or derived from another individual of the same species. 3. Of, or relating to the transplantation of tissue between individuals of the same species. 4. Correspondence in form or structure, owing to a similar environment. 5. (Of a tissue graft) derived from an individual of the same species as the recipient.

Homoplastic Morphological Characters: Characters similar in appearance, but have actually evolved from different ancestors. Homoplastic characters can distort patterns of relationship indicated by homologous characters because they are often in conflict with them. Octopus eyes and human eyes are homoplastic; they develop very differently and have evolved independently in two remotely related groups of animals.

Homozygous: Having the two genes at corresponding loci on homologous chromosomes identical for one or more loci. (Compare to heterozygous).

Horak: The standard author abbreviation Horak is used to indicate Prof. Dr. Egon Horak as the author when citing a mycological (fungal) name.

Hormone: A hormone (from Greek ὁρμή, "impetus") is a chemical released by a cell or a gland in one part of the body that sends out messages that affect cells in other parts of the organism. Only a small amount of hormone is required to alter cell metabolism. In essence, it is a chemical messenger that transports a signal from one cell to another.

Horns: Found on the heads of cystidia of some *Pluteus* species. Together these horns form an area shaped

similar to a crown.

Humus: In soil science, humus refers to any organic matter that has reached a point of stability, where it will break down no further and might, if conditions do not change, remain as it is for centuries, if not millennia.

Hyaline: Clear and uncolored as seen under the microscope.

Hyaline Apical Oil Drop: A clear (uncolored) drop at the top of a cell (usually in reference to a cystidia cell) that contains oil(s). See the description for *Psilocybe neocaledonica*.

Hyaline Drop: Some cystidia, especially when viewed in a fresh and natural state, possess a round and clear circle at the apex.

Hyaline Hyphae: Hyphae cells which are without color (clear).

Hygrophanous: The adjective hygrophanous refers to the color change of mushroom tissue (especially the pileus surface) as it loses or absorbs water, which causes the pileipellis to become more transparent when wet and opaque when dry.

Above: Hygrophanous *Panaeolus foenisecii* (=*Panaeolina foenisecii*) photographs taken about 15 minutes apart. Notice the fading of the cap from dark to light brown. Image courtesy Mycologist Jason Hollinger. View this observation at: http://mushroomobserver.org/4518?q=1yrLF

Hygroscopic: Readily absorbing moisture, as from the atmosphere.

Hymenial Cystidia: Cystidia found in the hymenium. There are two types: Cheilocystidia and pleurocystidia.

Hymenial Elements: Any element found on or within the hymenium.

Hymenial Surface: The surface of a mushroom gill where the spores and basidia can be seen.

Hymeniderm: 1. A conical layer composed of hymenium-like units. 2. A derm made up of non-septate elements originating at the same level and which transition between hymeniderm and epithelium. 3. A single-layered pileipellis. 4. With reference to the cortical layer, the cells are clavate and in a single layer.

Hymeniderm Pileipellis: The outer layer of the pileus consisting of hyphae tips.

Hymeniform Layer: Resembling a hymeniderm.

Hymeniform Surface: The spore-bearing surface of a gill. The surface of a gill.

Hymenium (Pl. hymenia or hymeniums): The spore-bearing surface of a mushroom is called the *hymenium*. It's a specialized layer of cells made up of basidia and their spores, as well as cystidia and "other cells." The gills constitute the *hymenium* of gilled mushrooms.

Hymenocarpous: A fruit body with a spore-bearing surface.

Hymenocystidium (Pl., Hymenocystidia, Hyménocystides): Any type of cystidia found on the spore-bearing surface of a mushroom.

Hymenogastraceae: The Hymenogastraceae are a family of fungi in the order Agaricales.

Hymenomycete: Hymenomycetes are the largest class of fungi within the phylum Basidiomycota. Many familiar fungi belong to this class, including bracket fungi and toadstools. This class contains the orders Agaricales, Boletales, and Russulales. Formerly a taxonomic group of basidiomycetes, now understood as polyphyletic assemblage of basidiomycetes, the term refers to fungi with fruit bodies whose hymenophore develops either not enclosed or only so with a veil (velum), which is called a gymnocarpic or hemiangiocarpic ontogeny, respectively. Puffballs, on the other hand, have gasterocarpic development (hymenophore enclosed).

Hymenophoral Trama: Another synonym for lamellar trama (ie gill trama).

Hymenophoral Trama Proper: Located below the hymenium and subhymenium in a gill. It consists of hyphae which project downwards from the pileus. The way in which these hyphae are arranged is helpful in identification.

Hymenophore: Literally means to bear the hymenium.

Hymenopodium: Tissue beneath the hymenium in certain fungi.

Hyper-Territorial Mycelium: Mycelium which begins to grow upon its own fruiting bodies only to begin to partially - nearly always unsuccessfully - digest its fruits for the sake of fruiting again.

Below: Courtesy Mycologist Mike Wallace

Hypha (pl. Hyphae) (Pronounced Hi-fuh and Highf-ay): A long, branching filamentous structure. In most fungi, hyphae are the main mode of vegetative growth, and are *collectively called a mycelium*.

Hyphal Coils (Coiled Hyphae, Coiling Hyphae, Coiled Mycelium): **zzz**

Hyphal Knot: Pre-primordial growth stage of mushrooms in which two hyphal mating types enjoin and form a more dense, robust, and round mass which precedes the mushroom fruitbody form.

Hyphal Pegs: Consisting of thick-walled more or less interwoven hymenial hyphae pushing up between basidia. Sometimes a single, very narrow, thick-walled, sub-acute hypha consitutes the peg.

Hyphal Tip (Hyphal Tips): The rounded area at the end of a hypha cell.

Hyphal Walls: The cell wall of a hypha cell.

Hyphoids (Hyphidia): Versiform cystidia usually devoid of contents, thin or thick-walled, and frequently so intricately branched so that the shape of the cystidium is complex. Types of hyphoids include: Asterophysis, Dendrophysis, Acanthophysis, and Dichophysis.

Hypoderm: A differentiated region just below the pileipellis or stipitipellis, in most instances the same as the subpellis.

Hypodermium: The tissue layer directly under the pileipellis.

Hypogeal (Hypogean, Hypogeic, and Hypogeous): Biological term describing an organism's activity below the soil surface.

IAPT: The International Association for Plant Taxonomy (IAPT) promotes an understanding of plant biodiversity, facilitates international communication of research between botanists, and oversees matters of uniformity and stability in plant names. The IAPT's primary purpose is the promotion and understanding of biodiversity—the discovery, naming, classification, and systematics of plants—for both living and fossil plants. Additionally, it promotes the study and conservation of plant biodiversity, and works to raise awareness of the general public to this issue. The organization also facilitates international cooperation among botanists working in the fields of plant systematics, taxonomy, and nomenclature. This is accomplished in part through sponsorship of meetings and publication of resources, such as reference publications and journals.

IBC (International Botanical Congress): An international meeting of botanists in all scientific fields, authorized by the International Association of Botanical and Mycological Societies (IABMS) and held every six years, with the location rotating between different continents. The current numbering system for the congresses starts from the year 1900. The IBC has the power to alter the ICN (International Code of Nomenclature for algae, fungi, and plants).

ICN: Abbreviation for The International Code of Nomenclature for algae, fungi, and plants. It was formerly the ICBN. It is the set of rules and recommendations dealing with the formal botanical names that are given to plants, fungi and a few other groups of organisms, all those "traditionally treated as plants." The rules are established by the IBC (International Botanical Congress). The International Association for Plant Taxonomy provides the supporting infrastructure. Each new edition of the ICN supersedes the earlier editions and is retroactive back to 1753.

ICBN: Formerly known as the International Code of Botanical Nomenclature and now known as the ICN (The International Code of Nomenclature for algae, fungi, and plants), this document regulates the international rules regarding taxonomy of plants, fungi, and other organisms similarly relevant.

Identifier: The name, number, or individual(s) corresponding with a specific collection held in an herbarium.

IGS: Inter-Genic Spacer.

Imbricate: Basidiocarps growing directly above one another.

Incipient Species: A group of organisms that is about to become a separate species from other, related individuals.

In Situ: In the natural or original position or place.

In Vitro: Taking place in a test tube, culture dish, or elsewhere outside a living organism.

In Vivo: Taking place in a living organism.

Inaequihymeniiferous: 1. Mushrooms with inaequihymeniiferous gills have intermittent spore maturation, causing the gills to develop spots as the spores mature. Examples of genera which often have species with inaequihymeniiferous gills include Coprinus, Lacrymaria and Panaeolus. This term was coined by mycologist Arthur Henry Reginald Buller in 1909. 2. The intermittent maturation and shedding of spores in radial bands beginning from the periphery of each gill, deliquescing from the bottom and advancing upwards.

Inamyloid: This term is used describe a lack of color change when a spore print is mounted in Melzer's reagent, Iodine, or Dilute Lugol's Solution. If there is no noticeable change in color, the spores are inamyloid.

Incertae Sedis: Incertae sedis (Latin for "of uncertain placement") is a term used to define a taxonomic group where its broader relationships are unknown or undefined. Alternatively, such groups are frequently referred to as "enigmatic taxa". Uncertainty at specific taxonomic levels is attributed by incertae familiae (of uncertain family), incerti subordinis (of uncertain suborder), incerti ordinis (of uncertain order) and similar terms.

Inclutions: Reference to the apex of certain cystidia in which crystal-like additions can be seen.

Incrusted (Synonymous with Encrusted): 1. Covered with a thin, hard crust; of hyphae, with matter located on their outer wall; of cystidia, covered with crystalline or amorphous deposit, particularly at the top. 2. Pigment situated on the outer side of the wall and visible as bands, granules, or patches.

Incrustations: 1. A crust or hard coating. 2. Pigment situated on the outer side of the wall and visible as bands, granules, or patches.

Indels (Indel Characters): Indel is a molecular biology term that has different definitions in different fields: In evolutionary studies, indel is used to mean an insertion or a deletion and indels simply refers to the mutation class that includes both insertions, deletions, and the combination thereof, including insertion and deletion events that may be separated by many years. In germline and somatic mutation studies, however, indel describes a special mutation class, defined as a mutation resulting in a colocalized insertion and deletion and a net gain or loss in nucleotides, and microindel is defined as an indel that results in a net gain or loss of 1 to 50 nucleotides.

Indole Alkaloid(s): Indole alkaloids are a class of alkaloids containing a structural moiety of indole; many indole alkaloids also include isoprene groups. Containing more than 4100 known different compounds, it is one of the largest classes of alkaloids. Many of them possess significant physiological activity and some of them are used in medicine. The amino acid tryptophan is the biochemical precursor of indole alkaloids.

Inequilateral: Having unequal sides; unsymmetrical or lopsided. This term, when applied to spores, is based on viewing a spore in "side-view" (if the spore is separated by drawing a longitudinal line and these two halves are not mirror images of one another).

Inflated (Inflation and Inflated Hyphae): Hyphae swollen or inflated.

Inflated-Ramose Subhymenium: A type of subhymenia in which the cells inflate and branch.

Inflexed: Pileus or pileus margin bent inwards.

Infrageneric: (As it relates to taxonomy) Pertaining to division or subclassification within a genus. A taxa or variation below the rank of genus.

Infundibuliform: Funnel-shaped.

Inocybaceae: The Inocybaceae are a family of fungi in the Agaricales order. According to a 2008 estimate, the family contains 13 genera and 821 species.[1] Members of this family have a widespread distribution in tropical and temperate areas.

Intercalary Inflated Cells: Inflated cells located in between their daughter cells.

Intercellular: Pigment situated between elements.

Interlamellar Arches: Arches located between the lammellae.

Interlamellar Space: The space between two gills. Abbreviated *i*.

Intermediate Species (Intermediate Collection) (Transitional Form(s)): A life form (species) that exhibits traits common to both an ancestral group and its derived descendant group. This is especially important where the descendant group is sharply differentiated by gross anatomy and mode of living from the ancestral group.

Intermediate Type Hyphae Patterns: In regard to gill trama, cap trama, and pileipellis forms - there are intermediate types (patterns which are a mixture of two patterns such as *subregular to irregular*.

Interpupillary Adjustment (Interpupillary Distance): All binocular microscopes allow the user to set the eyepieces at the correct distances for the width of the users eyes. Refer to the manual if it isn't obvious for your particular model.

International Code of Nomenclature for algae, fungi, and plants: The International Code of Nomenclature for algae, fungi, and plants (ICN) is the set of rules and recommendations dealing with the formal botanical names that are given to plants, fungi and a few other groups of organisms, all those "traditionally treated as plants". http://ibot.sav.sk/icbn/main.htm

Intervenose: Possessing veins between the lamellae.

Interwoven (Synonymous with Irregular): Refers to hyphae. Hyphae that are intricately entangled as they project downward from the pileus so that the hymenophoral trama proper is said to be interwoven (or irregular). The hyphal cells are often short, very curved and may or may not be isodiametric.

Interwoven Lamellar Hyphae: A type of gill trama in which the pattern weaves left to right.

Intracellular: In cell biology, molecular biology, and related fields, the word intracellular means *inside*

the cell.

Intraparietal Pigments (Synoymous with Membranary): A position of pigment on the inner portion of a wall, and usually in the form of spirals, rings, or irregular clumps.

Intricate Trichoderm: A trichoderm pileipellis made up of interwoven elements or cells.

Introgressive Hybridization: The spread of genes of one species into the gene complex of another as a result of hybridization between numerically dissimilar populations in which extensive backcrossing prevents formation of a single stable population.

Intron: Any nucleotide sequence within a gene that is removed by RNA splicing while the final mature RNA product of a gene is being generated. The term intron refers to both the DNA sequence within a gene and the corresponding sequence in RNA transcripts.

Intron Sequences: An intron is any nucleotide sequence within a gene that is removed by RNA splicing while the final mature RNA product of a gene is being generated. The term intron refers to both the DNA sequence within a gene and the corresponding sequence in RNA transcripts.

Inverse Gill Trama (Synonymous with Convergent): Having downward convergent hyphae that turn inward.

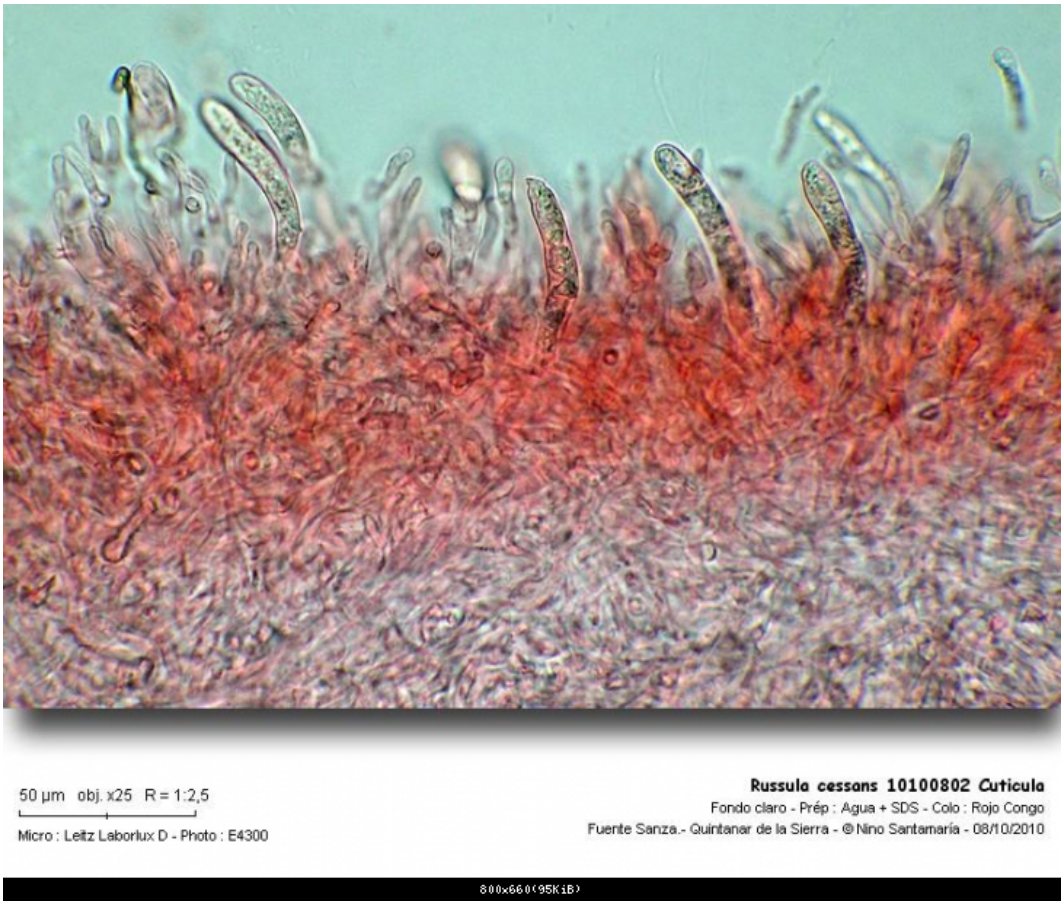
Involute: Margin of pileus rolled inward.

Ion: An ion is an atom or molecule in which the total number of electrons is not equal to the total number of protons, giving it a net positive or negative electrical charge.

Irregular Epithelium: Pileipellis form. An epithelium pileipellis made up of irregularly disposed elements or cells.

Irregular Trichoderm: Pileipellis form. A trichoderm pileipellis made up of irregularly placed (non-uniform) cells.

Below: Irregular Trichoderm Pileipellis (*Russula cessans*) courtesy Nino Santamaria



Isodiametric: Differentiated into cells of equal diameter in all dimensions.

Isolate: 1. A strain of a mushroom brought into pure culture (i.e. isolated) from a specific environment. Note that some mushrooms require multiple strains to fruit. 2. A substance isolated from an organism.

Isolate Selection: Cloning the most ideal mushroom from a multispore cultivation is one approach to selecting an isolate. Some instances of isolate selection will be based on the end result (one or two particularly desirable individual mushrooms) - versus guessing the best mycelium to choose from a petri dish. A bit more sector selection may still be necessary after cloning since an individual mushroom can be composed of more than one strain of mycelium. This method uses far fewer petri dishes and time than transferring mycelium from dish to dish with the same desire.

Isotype (Isotype Collection): Isotype is a duplicate specimen of the holotype, collected at the same time by the same person from the same population. (See also *Lectotype*).

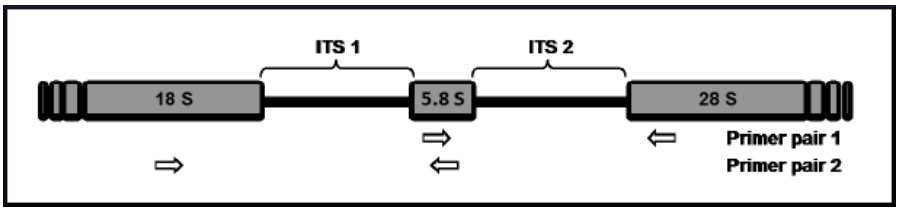
Isozyme: Isozymes (also known as isoenzymes or more generally as multiple forms of enzymes) are enzymes that differ in amino acid sequence but catalyze the same chemical reaction. These enzymes usually display different kinetic parameters (e.g. different KM values), or different regulatory properties. The existence of isozymes permits the fine-tuning of metabolism to meet the particular needs of a given tissue or developmental stage (for example lactate dehydrogenase (LDH)). In biochemistry, isozymes (or isoenzymes) are isoforms (closely related variants) of enzymes.

ITS: May refer to Internal Transcribed Spacer or the official ITS barcode region for identifying fungi. This region is highly variable among species and it is flanked by highly conserved regions. The high sequence

variability in the ITS allows us to distinguish between species, while the conserved regions (regions of low or no variation) flanking the ITS permit us to use the same primers for all fungi. As a result, the ITS region functions as a barcode for identification of fungal species. ITS (for internal transcribed spacer) refers to a piece of non-functional RNA situated between structural ribosomal RNAs (rRNA) on a common precursor transcript. Read from 5' to 3', this polycistronic rRNA precursor transcript contains the 5' external transcribed sequence (5' ETS), 18S rRNA, ITS1, 5.8S rRNA, ITS2, 28S rRNA and finally the 3'ETS.

ITS Alignment: A comparison of an ITS sequence to other ITS sequences to identify areas of similarity that may be a consequence of functional, structural, or evolutionary relationships between the sequences.

ITS Barcode: The official DNA barcode region to genetically identify, compare, and contrast fungi.



Above: *A digital drawing of the ITS region (Left to right: 18S gene, ITS1, 5.8S gene, ITS2, and 28S gene) with primer pairs aimed near ITS1 and ITS2.*

ITS rDNA: Internal Transcribed Space Ribosomal Deoxyribonucleic Acid.

ITS rDNA phylogeny: A phylogeny based on the ITS rDNA region.

ITS1 Nucleotide Synapomorphy: In cladistics, a synapomorphy or synapomorphic character state is a trait that is shared ("symmorphy") by two or more taxa and inferred to have been present in their most recent common ancestor, whose own ancestor in turn is inferred to not possess the trait.

ITS1 Region: Internal Transcribed Spacer 1 is a piece of non-functional RNA situated between structural ribosomal RNAs (rRNA) on a common precursor transcript. Read from 5' to 3', this polycistronic rRNA precursor transcript contains the 5' external transcribed sequence (5' ETS), 18S rRNA, ITS1, 5.8S rRNA, ITS2, 28S rRNA and finally the 3'ETS.

ITS2 Region: Internal Transcribed Spacer 2 is a region that is located between the 5.8S and 28S regions.

ITS2 Sequences: Sequences taken from the ITS2 region.

ITS rDNA Region: Internal Transcribed Spaced Ribosomal DNA region.

ITS Sequences: ITS (for internal transcribed spacer) refers to a piece of non-functional RNA situated between structural ribosomal RNAs (rRNA) on a common precursor transcript. The ITS region is now perhaps the most widely sequenced DNA region in fungi (Peay et al., 2008). It has typically been most useful for molecular systematics at the species level, and even within species (e.g., to identify geographic races). Because of its higher degree of variation than other genic regions of rDNA (for small- and large-subunit rRNA), variation among individual rDNA repeats can sometimes be observed within both

the ITS and IGS regions. In addition to the standard ITS1+ITS4 primers used by most labs, several taxon-specific primers have been described that allow selective amplification of fungal sequences (e.g., see Gardes & Bruns 1993 paper describing amplification of basidiomycete ITS sequences from mycorrhiza samples).

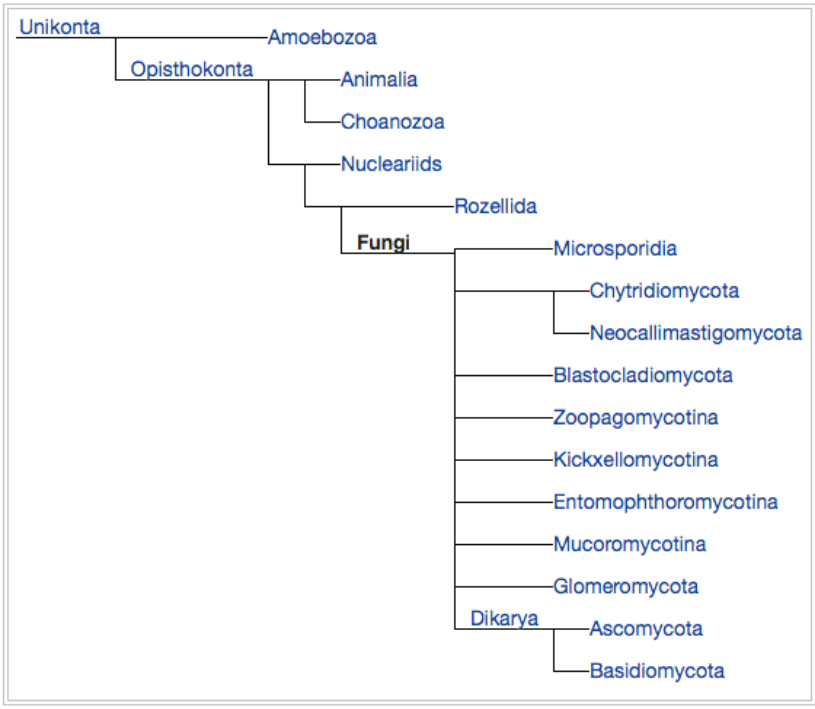
Ixo-: Gelatinous. Slime, typically that found on some species on the surface of the pileus.

Ixocutis: The outer surface of a mushroom where the hyphae compose a gelatinous horizontal layer and are lying flat.

Below: Ixocutis pileipellis of Cortinarius sp3 courtesy Nino Santamaria

Karyogamy: One of the two major modes of reproduction in fungi. In fungi that lack sexual cycles, it is an important source of genetic variation through the formation of somatic diploids. Karyogamy is the fusion of pronuclei of two cells, as part of syngamy, fertilization, or true bacterial conjugation.

Kingdom: In biology, kingdom (Latin: regnum, pl. regna) is a taxonomic rank, which is either the highest rank or in the more recent three-domain system, the rank below domain. Kingdoms are divided into smaller groups called phyla (in zoology) or divisions in botany. The complete sequence of ranks is life, domain, kingdom, phylum, class, order, family, genus and species. Currently, textbooks from the United States use a system of six kingdoms (Animalia, Plantae, Fungi, Protista, Archaea, and Bacteria) while British, Australian and Latin American textbooks may describe five kingdoms (Animalia, Plantae, Fungi, Protoctista and Prokaryota, or Monera).



Above: A 2014 Wikimedia Commons tree showing the current divisions in the Kingdom Fungi

Köhler illumination (Koehler illumination): To achieve the highest potential contrast in a specimen requires a **condenser** and **illumination system** that can be finely adjusted and centered. Some biological microscopes are equipped with a Köhler illumination system which features a **condenser** system and **bulb** that can be aligned, which is typically fitted with two **diaphragms** - one near the specimen and one near the lamp. The **upper diaphragm**controls the angle of the cone of light entering the specimen and the **lower diaphragm** controls the size of the circle of illumination.

Below: Setting Up Köhler Illumination

zzz Insert gallery here

Step 1. Let's begin with two things in mind: The microscope being used has this feature and the microscope is currently off. Begin by turning on the light source to about half way. If your microscope has a blue filter, now would be a good time to place it in the holder of the illuminator/light source/collector!

Step 2. Open the field diaphragm and the sub-stage condenser diaphragm all the way.

Step 3. Check the filter housing/holder and make sure the filter, if present, is centered.

Step 4. Raise the sub-stage condenser as high as you can.

Step 5. Place your prepared slide onto the stage while being cautious of the lenses.

Step 6. If necessary, move the stage so that the slide's mushroom material is centered over the upwardly projecting light path.

Step 7. Use the course focus knob to bring the stage to its highest height while being mindful of the slide

and the objectives. The slide should not be touching the objective.

Step 8. Look into the eyepiece(s) (or view thru a software program if you have a microscope imager/camera setup). You should see a narrow circle of light.

Step 9. Now, again using the course focus knob, go ahead and very slowly adjust the knob, transitioning the slide away from the objective(s). Your mushroom tissue should begin coming into focus at this point. You can now use the fine focus knob to improve the image.

Step 10. Close the field diaphragm as much as possible. Use the sub-stage condenser centering screws, center the light.

Step 11. Using the sub-stage condenser focusing knob, lower the sub-condenser until the light beam that you microscopically is in focus as much as possible - particularly at the edges of the light beam.

Step 12. Open the field diaphragm until the dark area is just out of view.

Step 13. Carefully adjust the sub-stage condenser diaphragm, then adjust the contrast without introducing artifacts and without losing detail.

Step 14. Your microscope should now be using Kohler illumination properly.

KOH: Potassium hydroxide. It has multiple uses for mycologists including rehydration of dried material, a mounting medium for microscope slides, and to observe color changes in either a microscope preparation or in the field on a fresh specimen. To make an approximate 5% solution of KOH in water simply add 3 grams of KOH material to a 2oz amber dropper bottle filled with distilled water. You can get away with a lower percentage KOH solution for microscopy, and it will be less aggressive to the cell walls of cells you are examining. Some mycologists use 2% KOH or less for microscopy. In the field 5-10% will work dramatically for macro-chemical spot tests as shown in Richard's pictures. Under 5% produces a slower and less well-defined reaction. Remember that KOH solution absorbs carbon dioxide from the air and becomes more and more dilute with time due precipitation of potassium carbonate (that white powdery stuff in the bottom of your bottle). Replace your KOH solution in an environmentally friendly way once the blurriness becomes visible in the dropper bottle.

Kummer: Mycologist and minister Paul Kummer of Germany (22 August 1834 – 6 Dec 1912). Kummer was a minister, teacher, and scientist in Zerbst, Germany, known most of all for his contribution to mycological nomenclature. Earlier classification of agarics by Elias Magnus Fries designated only a very small number of genera, with most species falling into *Agaricus*. These few genera were divided into a large number of tribi ("tribes"). In his 1871 work, *Der Führer in die Pilzkunde*, Kummer raised the majority of Fries tribi to the status of genus, thereby establishing many of the generic names for agarics that are in use to this day. Kummer published, among other works, *Der Führer in die Pilzkunde*, in 1871 (pages 21, 71) which established the genus *Psilocybe* in taxonomy. The standard author abbreviation P. Kumm. (or P.Kumm.) is used to indicate this individual as the author when citing a botanical name.

From 1857 to 1863, he worked as a private lecturer, then served as a curate in Zerbst (1863–1877).[1] From 1877 onward, he was a minister in Hann Munden.

l: (Lower case L). Abbreviation used when numbering the amount of lamellulae between two lamellae.

L: (Upper case L). Abbreviation for number of lamellae.

Labyrinthoid (Labyrinthinine, Labyrinthiform): Maze-like in appearance.

Laccate: Having a waxy or shiny surface (usually a pileus surface) that gives the appearance of a lacquered finish.

Lacryform: Tear-drop shaped.

Lacrymoid: Spores with confluent hilar appendage.

Lactifers: 1. Containing milky or similar exudation. 2. Hyphae possessing latex.

Lactiferous Hyphae: 1. Bearing a milky juice. 2. Hyphae that carry latex or are homologous to hyphae containing latex.

Lactophenol Cotton Blue: A stain. The preparation has three components: phenol, which will kill any live organisms; lactic acid which preserves fungal structures, and cotton blue which stains the chitin in the fungal cell walls.

Lageniform: Cystidia characterized by neck narrower than half width of cell body. See also narrowly lageniform and broadly lageniform.

Lagenocystidia: Small, thin- to thick-walled acuminate hymenocystidia with small crystals covering the apical part (Hyphodontia).

Lamella (pl., Lamellae): A synonym for gill(s). Lamellae is pronounced luh-mell-ee.

Lamellar Cystidia: A general term referring to any type of cystidia located on the gill.

Lamellar Trama (Synonymous with Gill Trama): The tissue inside a mushroom gill.

Lamellate: Having gills.

Lamellula (Pl., Lamellulae): The short gills originating from the outer peripheral edge of the cap but not fully extending to the stem. The presence (or absence) of these gills is sometimes important in identifying gilled mushrooms (ie The arrangement of the short-gills (random, in tiers, only occurring near the cap margin, etc).

Lamprocystidium (Pl., Lamprocystidia): 1. Lamprocystidia are entirely or at least partially thick-walled cystidia without distinguishable contents and are usually distinct from basidia. There's five subcategories of lamprocystidia: Seta, Setule, Setiform, Metuloid, and Mycosclerids. (See respective definitions). 2. Lamprocystidia (metuloids): thick-walled, short-fusiform tramal cystidia, which are encrusted over most

of their length; they may be modified gloeocystidia. The term is often used in a wide sense, including all more or less thick-walled encrusted cystidia.

Lanceolate Cystidia: Having the general shape of a lance; much longer than wide, with the widest part lower than the middle and a pointed apex.

Laterally Stipitate: Having a stem which extends off to the side, rather than straight down from the cap.

L - D: The length minus the diameter of spores.

LC–MS/MS: Liquid chromatography-tandem mass spectrometry. A method where a sample mixture is first separated by liquid chromatography before being ionised and characterised by mass-to-charge ratio and relative abundance using two mass spectrometers in series.

Lectotype: Lectotype is a specimen that is selected from the original material to serve as the type when no holotype was designated at the time of publication or if it was lost or destroyed. (See also *Neotype*).

Lecythiform: Shaped like a bowling pin, a flask, or a bottle.

leg.: Meaning "Specimen (or collection) collected by..."

Legitimately Published: (Reference to publishing a new species). Please see http://www.imafungus.org/Issue/2/13.pdf

Leiospore: Smooth-spored.

Length: (Of spores) distance between apex to bottom as seen in side view.

Lentiform: Shaped like a lens.

Leptocystidia: Thin-walled, smooth cystidia that have no distinguishable contents, are not tramal in origin, and are usually distinct from basidia. A type of leptocystidia are called brachycystidia - cells shaped like a stone walkway more or less.

Lichen: Lichens (/ˈlaɪkən/) are composite organisms consisting of a symbiotic relationship between a fungus (the mycobiont) and a photosynthetic partner (the photobiont or phycobiont), usually either a green alga (commonly Trebouxia) or cyanobacterium (commonly Nostoc). The morphology, physiology and biochemistry of lichens are very different from those of the isolated fungus and alga in culture. Lichens occur in some of the most extreme environments on Earth—arctic tundra, hot deserts, rocky coasts, and toxic slag heaps. However, they are also abundant as epiphytes on leaves and branches in rain forests and temperate woodland, on bare rock, including walls and gravestones, and on exposed soil surfaces (e.g., Collema) in otherwise mesic habitats. Lichens are widespread and may be long-lived; however, many are also vulnerable to environmental disturbance, and may be useful to scientists in assessing the effects of air pollution, ozone depletion, and metal contamination.

Life (cf. biota): A characteristic that distinguishes objects that have signaling and self-sustaining

processes from those that do not, either because such functions have ceased (death), or else because they lack such functions and are classified as inanimate. Biology is the science concerned with the study of life. Any contiguous living system is called an organism. These animate entities undergo metabolism, maintain homeostasis, possess a capacity to grow, respond to stimuli, reproduce and, through natural selection, adapt to their environment in successive generations. More complex living organisms can communicate through various means. A diverse array of living organisms can be found in the biosphere of Earth, and the properties common to these organisms—plants, animals, fungi, protists, archaea, and bacteria—are a carbon- and water-based cellular form with complex organization and heritable genetic information. Scientific evidence suggests that life began on Earth some 3.7 billion years ago. The mechanism by which life emerged is still being investigated. Since then, life has evolved into a wide variety of forms, which biologists have classified into a hierarchy of Taxa. Life can survive and thrive in a wide range of conditions. The meaning of life—its significance, purpose, and ultimate fate—is a central concept and question in philosophy and religion. Both philosophy and religion have offered interpretations as to how life relates to existence and consciousness, and both touch on many related issues, including life stance, purpose, conception of a god or gods, a soul or an afterlife. Different cultures throughout history have had widely varying approaches to these issues. Though the existence of life is only confirmed on Earth, many scientists believe extraterrestrial life is not only plausible but probable. Other planets and moons in the Solar System have been examined for evidence of having once supported simple life, and projects such as SETI have attempted to detect transmissions from possible alien civilizations. According to the panspermia hypothesis, life on Earth may have originated from meteorites that spread organic molecules or simple life that first evolved elsewhere.

Lignicolous: Growing on wood.

Lignin: Lignin (or "lignen") is a complex chemical compound most commonly derived from wood, and an integral part of the secondary cell walls of plants and some algae. The term was introduced in 1819 by de Candolle and is derived from the Latin word lignum, meaning wood. It is one of the most abundant organic polymers on Earth, exceeded only by cellulose, employing 30% of non-fossil organic carbon, and constituting from a quarter to a third of the dry mass of wood. As a biopolymer, lignin is unusual because of its heterogeneity and lack of a defined primary structure. Its most commonly noted function is the support through strengthening of wood (xylem cells) in trees.

Limoniform: Synoymous with citriniform. Lemon-shaped.

Linear: Lamellae with a straight edge that is parallel to upper side.

Linnaean Classification (Linnaean Taxonomy): The particular form of biological classification (taxonomy) set up by Carl Linnaeus, as set forth in his Systema Naturae (1735) and subsequent works. In the taxonomy of Linnaeus there are three kingdoms, divided into classes, and they, in turn, into orders, families, genera (singular: genus), and species (singular: species), with an additional rank lower than species. A term for rank-based classification of organisms, in general. That is, taxonomy in the traditional sense of the word: rank-based scientific classification. This term is especially used as opposed to cladistic systematics, which groups organisms into clades. It is attributed to Linnaeus, although he neither invented the concept of ranked classification (it goes back to Plato and Aristotle) nor gave it its present form. In fact, it does not have an exact present form, as "Linnaean taxonomy" as such does not really exist: it is a collective (abstracting) term for what actually are several separate fields, which use similar

approaches.

Liquid Culture (Abbrev. LC): This is mostly H2O with karo syrup (corn syrup) and mycelium. It can be prepared in one-pint glass jars. The original metallic lids are replaced in trade for plastic lids. Two holes are drilled through the lid: One with a 1/2" bit, the second with a 5/32" bit. One of these holes is filled with *super heavy-duty self healing injector ports* and acts as extraction sites via syringe and as oxygen exchange portals. The second opening will be used for fresh air exchange filtration using a *syringe Filter - 0.22 µm - PTFE*. These items can be glued to the lids using *Red Hi-Temp RTV Silicone*. The liquid solution itself is prepared by the meager combination of 1.5 cups water + 3 teaspoons Karo Light Corn Syrup. The lid is tightened and a tinfoil (aluminum foil) wrap is placed on top while pressure cooking at 15PSI for 30 minutes. Once cooled, the jars are quickly moved in front of a flow hood (or within a glove box). A pie slice of mycelium-covered agar is cut from a petri dish and carefully dropped into the opened jar, then resealed and stored in a tupperware container that has at least some oxygen exchange. The first few days the jars can either sit or encounter one-a-day gentle shakes to encourage mycelium expansion. New growth should emerge within a week and once-a-day shakes (gentle swirling motion is the goal) should occur. It is unknown to the author how long these jars will maintain, but a few months to a year should be well within reach, particularly when refrigeration is used once mycelium growth has reached its full potential. At any time necessary, a sterile syringe can extract liquid culture from the foam plug sites and be used to inoculate prepared rye spawn bags, jars, or tupperware containers.

LM (L.M.): Light Microscope.

Lobulate: Having small lobes.

Long Arm: Part of a chromosome (compare to Short Arm). They are separated from each other only by a primary constriction, the centromere, the point at which the chromosome is attached to the spindle during cell division.

Longitudinal Striations: Typically this is defined as long lines travelling in a vertical pattern along the stipe.

Lucus (Pl. Loci): In the fields of genetics and genetic computation, a locus (plural loci) is the specific location of a gene or DNA sequence on a chromosome. A variant of the DNA sequence at a given locus is called an allele. The ordered list of loci known for a particular genome is called a genetic map. Gene mapping is the procession of determining the locus for a particular biological trait. Diploid and polyploid cells whose chromosomes have the same allele of a given gene at some locus are called homozygous with respect to that gene, while those that have different alleles of a given gene at a locus, are called heterozygous with respect to that gene.

Longitudinal Section: A section that is cut along the long axis of a structure. Longitudinal section is the opposite of cross-section.

LSU rDNA: Large SubUnit ribosomal DNA. The LSU and SSU rRNAs are found within the large and small ribosomal subunits, respectively. The LSU rRNA acts as a ribozyme, catalyzing peptide bond formation. rRNA sequences are widely used for working out evolutionary relationships among organisms, since they are of ancient origin and are found in all known forms of life.

LSU Region: Large SubUnit DNA region of study.

Lubricous: (Usually referring to the pileus) Some pilei will have a gelatin-like pellicle (often removable), others a dry pileus, others a lubricous (or having an oily smoothness; slippery) pileus.

Lugol's Dilute Solution: Stain commonly used to view white-colored spores microscopically.

Lunate: Crescent-shaped.

Macnification: The Celestron digital imager will work with Mac computers thru *Photo Booth* but a noticeably higher quality in live video and captured images can be obtained through a program called *Macnification*. It includes measurement capability and you can save calibration settings for each objective. A "scale bar" can also be added in the bottom right of each image too. The drawbacks: It still requires a bit of work to use it for measuring and its currently sold at a high price. Here's the link: http://www.orbicule.com/macnification/.

Macroarray (DNA Macroarray): A DNA microarray (also commonly known as DNA chip or biochip) is a collection of microscopic DNA spots attached to a solid surface. Scientists use DNA microarrays to measure the expression levels of large numbers of genes simultaneously or to genotype multiple regions of a genome. Each DNA spot contains picomoles (10−12 moles) of a specific DNA sequence, known as probes (or reporters or oligos). These can be a short section of a gene or other DNA element that are used to hybridize a cDNA or cRNA (also called anti-sense RNA) sample (called target) under high-stringency conditions. Probe-target hybridization is usually detected and quantified by detection of fluorophore-, silver-, or chemiluminescence-labeled targets to determine relative abundance of nucleic acid sequences in the target.

Macrochemical Color Reactions: Chemical reactions to the the mushroom body oftentimes performed in situ or before performing microscopy.

Macrocystidia: 1. Macrocystidia is a genus of fungus in the Marasmiaceae family of mushrooms. The genus contains five species that collectively have a widespread distribution. 2. Posessing very large cystidia cells.

Macrofungi: Fungi producing macroscopically (as opposed to microscopically) visible bodies. Fungi that can be uprooted or picked by hand.

Macromorphology (Macromorphological, Macro-morphological): The gross structures or morphology of a mushroom visible with the unaided eye or at very low levels of magnification.

Macroscopic: 1. Large enough to be perceived or examined by the unaided eye. 2. Relating to observations made by the unaided eye.

Mango Form (Mango-Shaped): Refers to spore shape. Shaped literally like a mango fruit.

Margin: 1. The outer edge of the cap; the rim of the the cap. 2. The true gill edge.

Marcescent: 1. Able to revive when moistened. A mushroom which (unlike most species, described as "putrescent") can dry out, but later revive and continue to disperse spores. The genus *Marasmius* is well known for this feature, which was considered taxonomically important. 2. Pileus withers but remains attached to the stem.

Marginal Cells: Cells on the true gill edges, but not necessarily cystidia or basidioles. Sometimes these are septate marginal cells which are frustratingly difficult to decipher and separate from basidioles and club-shaped cheilocystidia.

Marginate Bulb: Bulb with a circular ridge.

Marginately Bulbous: Bulb of stem with a raised border.

Marmorate: Marbled. Faintly and irregularly striped or innately veined.

Mass Spectrometry: Mass spectrometry (MS) is an analytical technique that measures the mass-to-charge ratio of charged particles. It is used for determining masses of particles, for determining the elemental composition of a sample or molecule, and for elucidating the chemical structures of molecules, such as peptides and other chemical compounds. MS works by ionizing chemical compounds to generate charged molecules or molecule fragments and measuring their mass-to-charge ratios. In a typical MS procedure: A sample is loaded onto the MS instrument and undergoes vaporization.
The components of the sample are ionized by one of a variety of methods (e.g., by impacting them with an electron beam), which results in the formation of charged particles (ions). The ions are separated according to their mass-to-charge ratio in an analyzer by electromagnetic fields. The ions are detected, usually by a quantitative method. The ion signal is processed into mass spectra.

Mating Types: Different fungi myceliums can have different mating types. This describes they way two more mycelia can fuse together.

Mating-Type Loci (Mating-Type Locus) (MAT locus) (Mating type locus sequence): 1. A specialized region of the genome encoding key transcriptional regulators that direct regulatory networks to specify cell identity and fate. 2. In budding yeast, the locus that determines the mating type (α or a) of the haploid yeast cell.

Maximum Parsimony: Maximum parsimony is a character-based method that infers a phylogenetic tree by minimizing the total number of evolutionary steps required to explain a given set of data, or in other words by minimizing the total tree length.

Me: Median. The Median is the "middle number" (in a sorted list of numbers). To find the Median, place the numbers you are given in value order and find the middle number.

Measurand: A quantity intended to be measured.

Medallion Clamp: A clamp connection with an opening between the clamp connection itself and the elements connected by it.

Median Constriction: Transverse contraction in the middle.

Mediopellis: The middle layer in a pileipellis of three layers. (A stipitipellis and/or bubipellis can also have a multi-layered pellis (skin) in which the term mediopellis is applied.

Mediostratum: The central strand of a divergent gill trama.

Medullary Hyphae: 1. Longitudinally-arranged hyphae making up the stem surface. 2. A layer of loose threads (hyphae). **xyz**

MEGA5: (Molecular Evolutionary Genetics Analysis version 5), is software for mining online databases, building sequence alignments and phylogenetic trees, and using methods of evolutionary bioinformatics in basic biology, biomedicine, and evolution. The 2011 addition in MEGA5 is a collection of Maximum Likelihood (ML) analyses for inferring evolutionary trees, selecting best-fit substitution models (nucleotide or amino acid), inferring ancestral states and sequences (along with probabilities), and estimating evolutionary rates site-by-site.

Meiosis: (Pronounced my-oh-sys) The process (as it relates to gilled mushrooms) of cell division by which a single cell with a diploid nucleus subdivides into four cells with one haploid nucleus each. This takes place as the developing basidium (basidia) forms and transports nuclei within itself and into spores.

Melanized (e.g. Melanized Spores) (Sometimes synonymous with Dematiaceous): 1. To convert into or infiltrate with melanin. 2. Make or become black.

Melzer's Reagent: 1. Iodine solution used to test amyloidy and dextrinoidy of spores and other structures. 2. Melzer’s reagent is an iodine solution producing a blue-black “amyloid” reaction in some spores and parts of fungi. However, Melzer’s reagent contains chloral hydrate, a medically controlled substance and therefore it has been hard to get. The history of iodine use for identifi cation of fungi dates back to the mid 1800s; its use for white spore identification was described by Melzer in 1924. The production of the positive amyloid reaction is due to an amylose-iodine complex. In some cases a reddish “dextrinoid” color may occur due presumably to a glycine-betaine complex. The spores of 35 species of fungi were tested with Melzer’s, Lugol’s, and iodine solutions. All 35 species reacted as predicted from authoritative sources with Melzer’s but results were inconsistent with Lugol’s and iodine. Fungal tissue that turns blue or black with Melzer’s reagent is an amyloid positive reaction, sometimes written as I+ or J+.

Membrane: The thin, limiting covering of a cell or cell part. A pliable, sheet-like, and usually fibrous tissue that covers, lines, or connects fungi cells.

Membranous (Membranaceous): Like a membrane or skin-like or somewhat like kleenex.

Membranous Veil: A separate or separable (distinguished) tissue consisting of the veil that initially covers the gills by growing connected to both the cap margin to the stem until growth forces the veil to detach, exposing the gills and allowing spores to have more direct access to the air and ground upon ejection or detachment from their basidia.

Meristem: Actively dividing cells. Tissue usually made up of small cells capable of dividing indefinitely and giving rise to similar cells or to cells that differentiate to produce the definitive tissues and/or organs.

Metabolism: The set of life-sustaining chemical transformations within the cells of living organisms, including mushrooms. These enzyme-catalyzed reactions allow organisms to grow and reproduce, maintain their structures, and respond to their environments. The word metabolism can also refer to all chemical reactions that occur in living organisms, including digestion and the transport of substances into and between different cells, in which case the set of reactions within the cells is called intermediary metabolism or intermediate metabolism. Metabolism is usually divided into two categories. Catabolism breaks down organic matter, for example to harvest energy in cellular respiration. Anabolism uses energy to construct components of cells such as proteins and nucleic acids. The chemical reactions of metabolism are organized into metabolic pathways, in which one chemical is transformed through a series of steps into another chemical, by a sequence of enzymes. Enzymes are crucial to metabolism because they allow organisms to drive desirable reactions that require energy and will not occur by themselves, by coupling them to spontaneous reactions that release energy. As enzymes act as catalysts they allow these reactions to proceed quickly and efficiently. Enzymes also allow the regulation of metabolic pathways in response to changes in the cell's environment or signals from other cells. The metabolism of an organism determines which substances it will find nutritious and which it will find poisonous. For example, some prokaryotes use hydrogen sulfide as a nutrient, yet this gas is poisonous to animals. The speed of metabolism, the metabolic rate, influences how much food an organism will require, and also affects how it is able to obtain that food.

Metachromatic: Spore wall turns reddish to violet in solution of Chresyl Blue in H2O.

Metadata: Additional information that is associated with the collection. This includes the date, location, habitat, notes on appearance, smell, and taste.

Metagenomes: All of the genetic material present in an environmental sample, consisting of the genomes of many individual organisms.

Metagenomics: The study of metagenomes, genetic material recovered directly from environmental samples. The broad field may also be referred to as environmental genomics, ecogenomics or community genomics.

Metavelangiocarpic (Metavelangiocarpous): Secondary tissues emerge from the cap and/or stem forming an analogous veil to the universal veil.

Metuloid (Pl., Metuloids): 1. A cystidium which is not pointed at the end and has thick walls. 2. A lamprocystidium which is rounded at the apex or with a variable-shaped apex. A metuloid may or may not be encrusted, pigmented, inamyloid, dextrinoid, or amyloid.

Below: A metuloid cystidium seen in a *Hohenbuehelia* sp. (Courtesy Mycologist Tim Cannon)

Metuloid-type cystidium: Common in Inocybe species. It simply describes the shape of this particular cystidia. A cystidium which is not pointed at the end and has thick walls. Modified cystidium apically incrusted with calcium-oxalate, typically thick-walled.

Micaceus: Glistening with particles or spots on the pileus surface.

Micro (µ): Greek letter (µ). The symbol representing the micron. One µ is the same thing as one µm, one micron, and one micrometre/micrometer.

Microbe: A microbe or microorganism is a microscopic organism, which may be a single cell or multicellular organism. The study of microorganisms is called microbiology, a subject that began with Antonie van Leeuwenhoek's discovery of microorganisms in 1675, using a microscope of his own design. Microorganisms are very diverse and include all the bacteria and archaea and almost all the protozoa. They also include some members of the fungi, algae, and animals such as rotifers. Many macro animals and plants have juvenile stages which are also microorganisms. Some microbiologists also classify viruses as microorganisms, but others consider these as nonliving. Most microorganisms are microscopic, but there are some bacteria such as *Thiomargarita namibiensis* and some protozoa such as Stentor, which are macroscopic and visible to the naked eye.

Microbiology: The study of microscopic organisms, which are defined as any living organism that is either a single cell (unicellular), a cell cluster, or has no cells at all (acellular). This includes eukaryotes, such as fungi and protists, and prokaryotes.

Microchemical Reaction: Microscopically observed reaction of a chemical on tissue.

Micrograph: A photograph taken through a microscope or a drawing of an object as seen through a microscope.

Micromanipulator: A device which is used to physically interact with a sample under a microscope, where a level of precision of movement is necessary that cannot be achieved by the unaided human hand. It may typically consist of an input joystick, a mechanism for reducing the range of movement and an output section with the means of holding a microtool to hold, inject, cut or otherwise manipulate the object as required. The mechanism for reducing the movement usually requires the movement to be free of backlash. This is achieved by the use of kinematic constraints to allow each part of the mechanism to move only in one or more chosen degrees of freedom, which achieves a high precision and repeatability of movement, usually at the expense of some absolute accuracy.

Micromorphology (Micromorphological, Micro-morphological): The fine-level structures or morphology of an organism, mineral, or soil component visible through microscopy.

Microscopy: Pronounced my-craus-ska-pea. Microscopy is the technical field of using microscopes to view samples and objects that cannot be seen with the unaided eye (objects that are not within the resolution range of the normal eye). There are three well-known branches of microscopy: optical, electron, and scanning probe microscopy.

Microstructure: The fine structure of a material or tissue as revealed by microscopy.

Misappl.: Misapplied.

Mitic System: 1. The E. J. H. Corner system of Hyphal Analysis established in 1932.

Mitochondrial DNAs: DNA (plural DNAs) found in mitochondria, which contain some structural genes and is generally inherited only through the female line. Mitochondrial DNA (mtDNA or mDNA) is the DNA located in organelles called mitochondria, structures within eukaryotic cells that convert chemical energy from food into a form that cells can use, adenosine triphosphate (ATP). Nearly all of the DNA present in eukaryotic cells can be found in the cell nucleus, and in plants, the chloroplast as well.

Mitochondrian (Pl., Mitochondria): A membrane-enclosed organelle found in most eukaryotic cells. Mitochondria are the cell's power producers (ATP). They convert energy into forms that are usable by the cell.

Mitosis: (Pronounced my-toe-sys) The nonsexual process of nuclear division in a cell by which the chromosomes of one nucleus are replicated and divided equally into two daughter nuclei.

ML: Maximum Likelihood.

ML Tree: A phylogenetic tree based on Maximum Likelihood. This is a method of inferring phylogenetic relationships using a pre-specified (often user-specified) model of sequence evolution.

M.M. Moser: The standard author abbreviation M.M. Moser is used to indicate Dr. Meinhard Michael Moser

as the author when citing a botanical or mycological name.

Molecular Data: Usually referring to DNA sequencing study.

Molecular Lab: A lab that does DNA sequencing.

Molecular Markers: In genetics, a molecular marker (identified as genetic marker) is a fragment of DNA that is associated with a certain location within the genome. Molecular markers are used in molecular biology and biotechnology to identify a particular sequence of DNA in a pool of unknown DNA.

Molecular Phylogenetics (Molecular Phylogeny): the analysis of hereditary molecular differences, mainly in DNA sequences, to gain information on an organism's evolutionary relationships. The result of a molecular phylogenetic analysis is expressed in a phylogenetic tree. Molecular phylogenetics is one aspect of molecular systematics, a broader term that also includes the use of molecular data in taxonomy and biogeography.

Molecular Sequence Data: Synonymous with DNA sequencing results.

Molecular Systematics (Biological Systematics, Molecular Studies): The DNA (molecular) study of the diversification of living forms, both past and present, and the relationships among living things through time. Relationships are visualized as evolutionary trees (synonyms: cladograms, phylogenetic trees, phylogenies) - based on DNA sequencing results. Phylogenies have two components, branching order (showing group relationships) and branch length (showing amount of evolution). Phylogenetic trees of species and higher taxa are used to study the evolution of traits (e.g., anatomical or molecular characteristics) and the distribution of organisms (biogeography). Systematics, in other words, is used to understand the evolutionary history of life on Earth.

Moniliform: Cystidia that are cylindrical but contracted at regular intervals, like a string of beads.

Monoangiocarpous: Having a single veil instead of two or more veils.

Monobasidiospores: Single basidiospores. Individual spores isolated for study.

Monoevalangiocarpy: A type of angiocarpic development in which only a universal veil participates.

Monograph: A monograph is a work of writing upon a single subject, usually by a single author. It is often a scholarly essay or learned treatise, and may be released in the manner of a book or journal article. It is by definition a single document that forms a complete text in itself. An author may therefore declare her or his own work to be a monograph by intent, or a reader or critic might define a given text as a monograph for the purpose of analysis. Normally the term is used for a work intended to be a complete and detailed exposition of a substantial subject at a level more advanced than that of a textbook. However, the leading textbooks in a field are usually written as a large monograph, in that they put forward original ideas, draw on original material, and are agenda setting. Some textbooks are of such a quality that their individual chapters read as monographs. Such textbooks are considered to be classics within their field. Likewise, many monographs are less than agenda setting and some are of a weaker descriptive nature. Monographs form a component of the review of literature in science and engineering.

Monokaryon (Monokaryotic): Having one nucleus as opposed to two or more. Constrast the term *monkaryotic* with *dikaryotic*.

Monomitic: 1. A category of gill trama hyphae having only one type of hyphae pattern, *generative hyphae*, (which are thin-walled, branched, narrow [1.5-10microns], and septate). Contrast the term *monomitic* with *dimitic* and *trimitic*.

Monophyletic (Monophyly): A taxon that includes the common ancestor and all of its descendants. Monophyly means common descent from a single ancestor. In common cladistic usage, a monophyletic group is a taxon (group of organisms) which forms a clade, meaning that it consists of a species and all its descendants. The term is synonymous with the uncommon term holophyly. Monophyletic groups are typically characterized by shared derived characteristics (synapomorphies). Monophyly is contrasted with the terms *paraphyly* and *polyphyly*.

Monosaccharides: The most basic units of biologically important carbohydrates. They are the simplest form of sugar and are usually colorless, water-soluble, crystalline solids.

Monospore (Monospores): A simple or undivided non-motile, asexual spore.

Monosporidial: of, from, or relating to a single sporidium.

Monosporous: Reproduction via monospores.

Monotypic: Having a single representative. Used especially when a genus has only one species.

Monotypic Genus: In botany, a monotypic taxon is a taxon that has only one species.

Monotypic Section: A section with only one species.

Monotypic Subgenus: A single species listed below genus and above species, usually within a section or clade.

Monovelangiocarpy (Monovelangiocarpous): A type of angiocarpic development of the basidiocarp in which only a universal veil participates. Hymenium covered by a single veil during development. Having a single universal veil protecting the primordia.

Montage: In Macnification this feature is a group of images shared in a PDF file side-by-side. Other programs use montage differently.

Morph (Pl., Morphs): One of various distinct forms of a microstructure or species.

Morphological Variation: The variation in plain site (macromorphological) attributes or microscopic structures (micromorphological) within a given study - usually in reference to species variation among many collections (or with reference to genus variation after analyzing many collections of each species).

Morphology (Morphologically): In biology, morphology is a branch of bioscience dealing with the study of the form and structure of organisms and their specific structural features. This includes aspects of the outward appearance (shape, structure, color, pattern) and inward structure. In *Agaricales*, morphology is often dealt with in two branches: Macromorphology and micromorphology.

Morphospecies Concept: A species concept different from biological or phylogenetic species concepts. It asserts that species is a diagnosable cluster of individuals within which there is a pattern of ancestry and descent, and beyond which there is not.

Morphotypes: Any of a group of different types of individuals of the same species in a population; a morph.

Moss: Mosses are small, soft plants that are typically 1–10 cm (0.4–4 in) tall, though some species are much larger. They commonly grow close together in clumps or mats in damp or shady locations. They do not have flowers or seeds, and their simple leaves cover the thin wiry stems. At certain times mosses produce spore capsules which may appear as beak-like capsules borne aloft on thin stalks. There are approximately 12,000 species of moss classified in the Bryophyta. The division Bryophyta formerly included not only mosses, but also liverworts and hornworts. These other two groups of bryophytes now are often placed in their own divisions.

Mottled: Mark with spots or smears of color.

Mount: Term used to describe adding a liquid such as KOH or soap water to a section of material before a cover slip is added.

MP: Most Parsimonious.

MP Tree (MPT): Most Parsimonious Tree.

MrBayes: A software program which performs Bayesian inference of phylogeny.

MRCA (MRCAs): Most Recent Common Ancestor(s).

mtSSU-rDNA: Mitochondrial Small SubUnit Ribosomal DNA.

Mucilaginous: Consisting of mucilage (viscous substance). Resembling mucilage; moist and sticky.

Mucous: Pileus or stipe surface is slimy.

Mucro: Crested as in the cystidia of Pluteus cervinus and Pleuroflammula. Cystidia in which the apex narrows abruptly into a pointed protuberance.

Mucronate: Cystidia with small abrupt, acute, or blunt protuberance at the apex. Or having a short apical extension.

Muricate: With hard excrescence.

Multi-Gene Phylogeny (Multi-Gene Phylogenies): Analyzing and comparing multiple genes between collections.

Multiple Sequence Alignment(s) (MSA): A sequence alignment of three or more biological sequences, generally Protein, DNA, or RNA.

Murrill: The standard author abbreviation Murrill is used to indicate William Alphonso Murrill (1869–1957) as the author when citing a mycological name.

Above: Dr. William Alphonso Murrill (1869–1957)

Muscarine: Muscarine, L-(+)-muscarine, or muscarin is a natural product found in certain mushrooms, particularly in Inocybe and Clitocybe species, such as the deadly C. dealbata. Mushrooms in the genera Entoloma and Mycena have also been found to contain levels of muscarine which can be dangerous if ingested. Muscarine has been found in harmless trace amounts in Boletus, Hygrocybe, Lactarius and Russula. Muscarine is only a trace compound in the fly agaric Amanita muscaria; the pharmacologically more relevant compound from this mushroom is muscimol. The A. muscaria contains a variable dose of muscarine, usually around 0.0003% fresh weight. This is very low and toxicity symptoms occur very rarely. Inocybe and Clitocybe contain muscarine concentrations up to 1.6%. Muscarine was first isolated from Amanita muscaria in 1869. It was the first parasympathomimetic substance ever studied and causes profound activation of the peripheral parasympathetic nervous system that may end in convulsions and death. It is a nonselective agonist of the muscarinic acetylcholine receptor.

Mushroom: The fleshy, spore-bearing fruiting body of a fungi, typically produced above ground on soil or on its food source (decomposing wood, etc). The word "mushroom" is most often applied to those fungi (Basidiomycota, Agaricomycetes) that have a stem (stipe), a cap (pileus), and gills (lamellae). Some mycologists use the term in a more relaxed sense, applying the term "mushroom" to non-gilled fungi.

Mutagenized: Treat (a cell, organism, etc.) with mutagenic agents. To cause or induce mutation in (a cell or an organism).

Mutant: In biology and especially genetics, a mutant is an organism or a new genetic character arising or resulting from an instance of mutation, which is a base-pair sequence change within the DNA of a gene or chromosome of an organism resulting in the creation of a new character or trait not found in the wild type. The natural occurrence of genetic mutations is integral to the process of evolution. The study of mutants is an integral part of biology; by understanding the effect that a mutation in a gene has, it is possible to establish the normal function of that gene.

Mutation: In genetics, a mutation is a change of the nucleotide sequence of the genome of an organism, virus, or extrachromosomal genetic element. Mutations result from unrepaired damage to DNA or to RNA genomes (typically caused by radiation or chemical mutagens), errors in the process of replication, or from the insertion or deletion of segments of DNA by mobile genetic elements. Mutations may or may not produce discernible changes in the observable characteristics (phenotype) of an organism. Mutations play a part in both normal and abnormal biological processes including: evolution, cancer, and the development of the immune system. Mutation can result in several different types of change in sequences. Mutations in genes can either have no effect, alter the product of a gene, or prevent the gene from functioning properly or completely. Mutations can also occur in nongenic regions.

Mycelial Cord (Mycelial Cords, Mycelial Chord, Mycelial Chords): Linear aggregations of parallel hyphae. Mature cords are made up of wide, empty vessel hyphae surrounded by narrower sheathing hyphae. Cords may look similar to plant roots, and also frequently have similar functions; hence they are also called rhizomorphs (literally, "root-forms"). Mycelial cords are capable of transferring nutrients over long distances. They can transfer nutrients to a developing fruiting body, or enable wood-rotting fungi to grow through soil from an established food base in search of new food sources.

Above: Mycelial chords courtesy Wikimedia Commons

Mycelial Fan: An oriental fan-like formation of fungal hyphae. A fan-shaped mycelial mat forming under the bark and wood of roots or lower trunks, typically referenced with Armillaria species on tree farms and forests.

Above: A mycelial fan of field-identified *Armillaria solidipes* sensu lato

Mycelial Fragmentation: Many fungi can reproduce by fragmentation. Any mycelium that is fragmented or disrupted, provided that the fragment contains the equivalent of the peripheral growth zone, can grow into a new colony. Many fungi are sub-cultured using this hyphal fragment technique. When mycelial fragmentation occurs, the mycelium breaks into two or more similar fragments either accidentally or due to some external force. Each fragment grows into a new mycelium. (a) Accidental: The mycelium accidentally breaks up into several fragments each one will develop into a new individual. (b) Purposive: Fragmentation of the mycelium takes place as a normal means of propagation. The hypha breaks up into individual cells. Each group of isolated cells can develop a new individual.

Mycelium (pl., mycelia): A branching network of hyphae. This is oftentimes a white, strand-like material which produces the mushroom body.

Mycenoid: Resembling a mushroom of the genus Mycena: tall, slender mushrooms with long cartilaginous stems (no ring or volva), and comparatively small conic to bellshaped caps with attached but not decurrent gills.

Myco: Formed irregularly from Greek *mukes* (=fungus, mushroom).

Mycobiota (Mycobiotas): A group of all the fungi present in a particular geographic region (e.g. "the mycobiota of Ireland") or habitat type (e.g. "the mycobiota of Northern Africa").

Mycoflora (Mycofloras): The fungi living within of a particular environment.

Mycological: A term used to denote relevancy within the study of fungi (mycology). It can be contrasted with the word *botanical*.

Mycologist (Synonym "Mychologist"): An individual involved in the study of fungi - including their genetic and biochemical properties, their taxonomy, and their use to humans as a source for medicine (e.g., penicillin), food (e.g., beer, wine, cheese, edible mushrooms), as well as their dangers - such as poisoning or infection.

Mycology: The branch of biology concerned with the study of fungi, including their genetic and biochemical properties, their taxonomy and their use to humans as a source for tinder, medicinals (e.g., penicillin), food (e.g., beer, wine, cheese, edible mushrooms) and entheogens, as well as their dangers, such as poisoning or infection. From mycology arose the field of phytopathology, the study of plant diseases, and the two disciplines remain closely related because the vast majority of "plant" pathogens are fungi. A biologist who studies mycology is called a mycologist.

Mycoparasitism: Mycoparasitism occurs when any fungus feeds on other fungi, a form of parasitism, our knowledge of it in natural environments is very limited.

Mycophagy: Fungivory or mycophagy is the process of organisms consuming fungi. Many different organisms have been recorded to gain their energy from consuming fungi, including birds, mammals, insects, plants, amoeba, gastropods, nematodes and bacteria. Some of these, which only eat fungi are called fungivores whereas others eat fungi as only part of their diet, being omnivores.

Mycophilic Fungi: Fungi which grow on sporocarps of other fungi or slime moulds.

Mycorrhizal: A mycorrhiza (pl. mycorrhizae or mycorrhizas) is a symbiotic (generally mutualistic, but occasionally weakly pathogenic) association between a fungus and the roots of a vascular plant. In a mycorrhizal association, the fungus colonizes the host plant's roots, either intracellularly as in arbuscular mycorrhizal fungi (AMF), or extracellularly as in ectomycorrhizal fungi. They are an important component of soil life and soil chemistry.

Mycoscleroids: Lamprocystidia that are embedded in the trama (seta, setules, setiform lamprocystidia and metuloids are all either dermatocystidia or hymenial cystidia).

Myxosporium: The set of often mucilaginous layers on the outside of the basidiospore wall enveloping the eusporium. Its components are ectosporium, perisporium, and exosporium.

Mycota (Mycotas): An alternative taxonomic name for the Kingdom Fungi.

Mycovirus: Mycoviruses (ancient Greek μύκης mykes: fungus and Latin virus) are viruses that infect fungi. The majority of mycoviruses have double-stranded RNA (dsRNA) genomes and isometric particles, but approximately 30% have positive sense, single-stranded RNA (+ssRNA) genomes. To be a true mycovirus, they must demonstrate an ability to be transmitted - in other words be able to infect other healthy fungi. Many double stranded RNA elements that have been described in fungi do not fit this description, and in these cases they are referred to as virus like particles or VLPs. Preliminary results indicate that most mycoviruses codiverge with their hosts, i.e. their phylogeny is largely congruent with the one of their hosts. However, many virus families containing mycoviruses have only sparsely been sampled.

n: Number of basidiospores measured.

Nacreous: Having a pearly lustre. Any gelatinized tissue as seen in alkali solutions.

Napiform: Shaped like a turnip.

NaOCI: Bleach. Usually a 10% solution (90% water) is used for an alternative sterilizing method during cloning.

NaOH: Sodium hydroxide, also known as lye and caustic soda, with the molecular formula NaOH is a highly caustic metallic base which is a white solid available in pellets, flakes, granules, and as a 50% saturated solution.

Narrowly Clavate: Club-shaped cystidia with a Q greater than 4.

Narrowly Conicial: Conical cystidia with a Q greater than 4.

Narrowly Cylindrical: Cylindrical cystidia with a Q greater than 4.

Natural Selection: Natural selection is the gradual, non-random process by which biological traits become either more or less common in a population as a function of differential reproduction of their bearers. It is a key mechanism of evolution. The term "natural selection" was popularized by Charles Darwin who intended it to be compared with artificial selection, what we now call selective breeding. Variation exists within all populations of organisms. This occurs partly because random mutations cause changes in the genome of an individual organism, and these mutations can be passed to offspring. Throughout the individuals' lives, their genomes interact with their environments to cause variations in traits. (The environment of a genome includes the molecular biology in the cell, other cells, other individuals, populations, species, as well as the abiotic environment). Individuals with certain variants of the trait may survive and reproduce more than individuals with other variants. Therefore the population evolves. Factors that affect reproductive success are also important, an issue that Charles Darwin developed in his ideas on sexual selection, for example. Natural selection acts on the phenotype, or the observable characteristics of an organism, but the genetic (heritable) basis of any phenotype that gives a reproductive advantage will become more common in a population. Over time, this process can result in populations that specialize for particular ecological niches and may eventually result in the emergence of new species.

NCBI: National Center for Biotechnology Information.

NCBI Identifier: The two types of sequence identification numbers, GI and VERSION, have different formats and were implemented at different points in time. GI number (sometimes written in lower case, "gi") is simply a series of digits that are assigned consecutively to each sequence record processed by NCBI. The GI number bears no resemblance to the Accession number of the sequence record. Nucleotide sequence GI number is shown in the VERSION field of the database record protein sequence GI number is shown in the CDS/db_xref field of a nucleotide database record, and the VERSION field of a protein database record VERSION is made of the accession number of the database record followed by a dot and a version number (and is therefore sometimes referred to as the "accession.version") nucleotide sequence version contains two letters followed by six digits, a dot, and a version number (or for older nucleotide sequence records, the format is one letter followed by five digits, a dot, and a version number) protein sequence version contains three letters followed by five digits, a dot, and a version number. The GI number has been used for many years by NCBI to track sequence histories in GenBank and the other sequence databases it maintains. The VERSION system of identifiers was adopted in February 1999 by the International Nucleotide Sequence Database Collaboration (GenBank, EMBL, and DDBJ). More details are given in the historical note, below. The two systems of identifiers run in parallel to each other. That is, when any change is made to a sequence, it receives a new GI number AND an increase to its version number.

Necropigmented Basidia: Basidia that become ochraceous and collapse with age.

Neotype: Neotype is a specimen derived from a non-original collection that is selected to serve as the type as long as all of the material on which the name was originally based is missing.

Nettle Hair-Shaped: Lageniform cystidia with long, narrow, slender neck.

NH3 = Anydrous ammonia

NH4: The ammonium (more obscurely: aminium) cation is a positively charged polyatomic cation with the chemical formula NH_4^+.

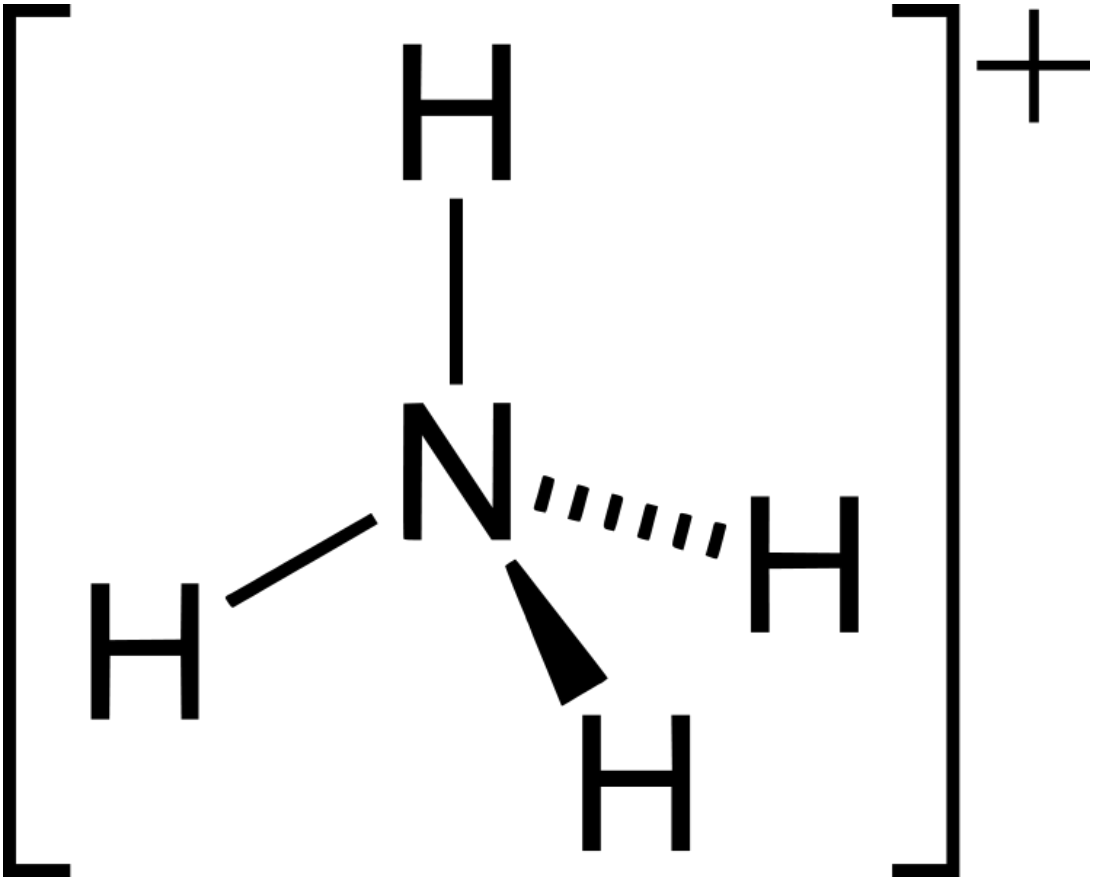
NH4OH: Ammonia solution, also known as ammonium hydroxide, ammonia water, ammonical liquor, ammonia liquor, aqua ammonia, aqueous ammonia, or simply ammonia, is a solution of ammonia in water. It can be denoted by the symbols $NH_3(aq)$. Ammonium Hydroxide can be used as an alternative to KOH and . A 10% solution is common, with some mycologists preferring a 2.5%, 3%, or 5% solution. It should be noted here that Ammonium Hydroxide is listed as corrosive and a small amount will release powerful fumes into the work area. A benefit in working with it, however, is found in comparison to KOH - it does not leave a crystallized (solid state) residue upon drying. This solution should be handled with the appropriate level of care and respect. Note: A 4oz bottle of 20% Ammonium Hydroxide can be diluted to 10% by adding 4oz of distilled water.

Nitrate: Nitrate is a polyatomic ion with the molecular formula NO_3^-. Nitrates also describe the organic functional group $RONO_2$. Nitrites are produced by a number of species of nitrifying bacteria. The main nitrates are ammonium, sodium, potassium, and calcium salts.

Nitrogen Fixation (Fix Nitrogen): Nitrogen fixation is a process by which nitrogen (N_2) in the atmosphere

is converted into ammonium (NH_4). Atmospheric nitrogen or molecular nitrogen (N_2) is relatively inert: it does not easily react with other chemicals to form new compounds. The fixation process frees up the nitrogen atoms from their diatomic form (N_2) to be used in other ways. Nitrogen fixation, natural and synthetic, is essential for all forms of life because nitrogen is required to biosynthesize basic building blocks of plants, animals and other life forms (e.g., nucleotides for DNA and RNA and amino acids for proteins). Nitrogen fixation also refers to other biological conversions of nitrogen, such as its conversion to nitrogen dioxide. Biological nitrogen fixation (BNF) occurs when atmospheric nitrogen is converted to ammonia by an enzyme called nitrogenase. The reaction for BNF is: $N_2 + 8\ H^+ + 8\ e^- \rightarrow 2\ NH_3 + H_2$.

Above: Nitrogen (N_2) skeletal formula before fixation



Above: Ammonium (NH_4) skeletal formula

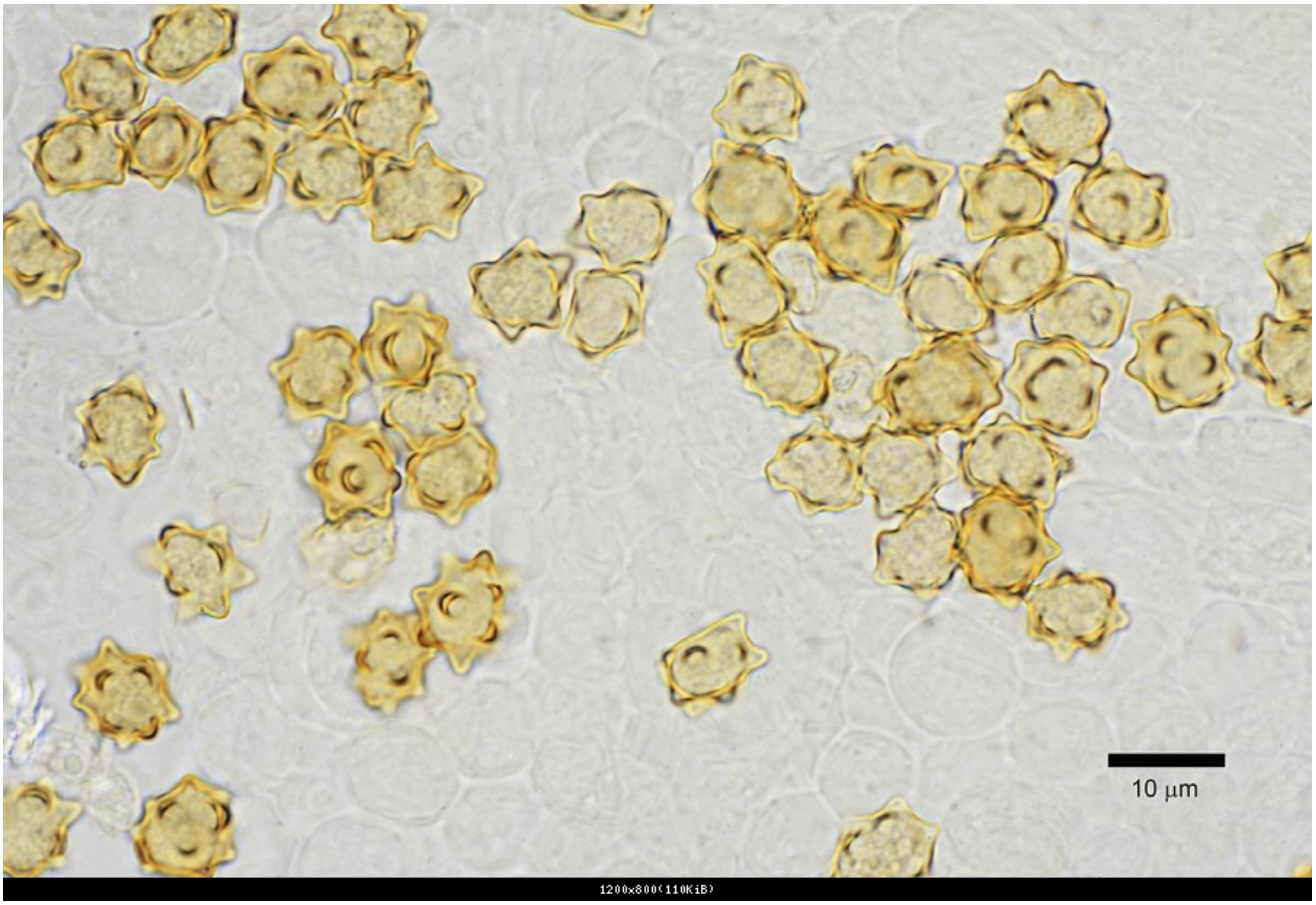
nLSU: Nuclear Large SubUnit.

Nodose: With rounded thickenings (nodes) at more or less regular intervals (along the axis of a lobe or branch).

Nodular: Describes spore shape where small, knoblike outgrowths (proturbences) are evident.

Nodulose: Describes spore shape where small, knoblike outgrowths (proturbences) are evident. Spores

with small knots.



Above: Nodulose spores from the genus *Inocybe* courtesy Linas Kudzma (See MO Observation)

nom.: Name.

nom. conserve: Nomen conservandum. A biological taxonomic name that is preserved by special sanction in exception to the usual rules.

nom. et gen. nov.: Name and genus new.

nom. et stat. nov.: Name and status new.

nom. nov.: Nomen novum (New name or new replacement name).

nom. nud.: Nomen nudum. A proposed taxonomic name that is invalid because the group designated is not described or illustrated sufficiently for recognition, that has no nomenclatural status, and that consequently can be used as though never previously proposed.

nom. rev., comb. nov.: Name revised, combination new.

Nomenclature: Nomenclature is a term that applies to either a list of names or terms, or to the system of principles, procedures and terms related to naming - which is the assigning of a word or phrase to a particular object or property. (See also *International Code of Nomenclature for algae, fungi, and plants*).

Nomen Dubium: A nomen dubium (Latin for "doubtful name", plural nomina dubia) is a scientific name that is of unknown or doubtful application. Note that in botanical nomenclature the phrase nomen dubium has no status, although it (or more often its synonym nomen ambiguum) are informally used for names whose application has become confusing. In botany, such names may be proposed for rejection. In case of a nomen dubium it may be impossible to determine whether a specimen belongs to that group or not. This may happen if the original type series (i. e. holotype, isotypes, syntypes, and paratypes) is lost or destroyed. The zoological and botanical codes allow for a new type specimen, or neotype, to be chosen in this case.

nom. et gen. nov.: Name and genus new.

Nomen Nudum (Pl., Nomina Nuda): The phrase nomen nudum (plural nomina nuda) is a Latin term, meaning "naked name", used in taxonomy (especially in zoological and botanical nomenclature). It may or may not be written in italics, depending on style. The term is used to indicate a designation which looks exactly like a scientific name of an organism, and may well have originally been intended to be a scientific name, but fails to be one because it has not (or has not yet) been published with an adequate description (or a reference to such a description), and thus is a "bare" or "naked" name, one which cannot be accepted as it currently stands. Because a nomen nudum fails to qualify as a formal scientific name, a later author can publish a real scientific name that is identical in spelling. If one and the same author puts a name in print, first as a nomen nudum and later on publishes it for real, accompanied by a description that does meet the formal requirements, then the date of publication of the latter, formally correct publication becomes the name's date of establishment.

Nom. Prov. (nom. prov.): The phrase "nom. prov." is an abbreviation for the term nomem provisorium which means, "a provisional name or a name that may be changed in the future." An example of this would be *Ps. montanta* (nom. prov.) which will soon officially be changed to the scientific name *Deconica montana*. It is only properly used when we know for a fact that the present name of the species will be changed in the scientific literature.

non: Not.

Non-Amyloid: Not changing color or turning yellowish in Melzer's reagent.

Non-Stipitate: Lacking a stem (stipe).

Norbaeocystin (Synonymous with Nor-Baeocystin and Neobaeocystin): Norbaeocystin is a psilocybin mushroom alkaloid and analog of psilocybin. It is found as a minor compound in most psilocybin mushrooms together with psilocin, psilocybin and baeocystin. Norbaeocystin is a N-demethylated derivative of baeocystin (itself a N-demethylated derivative of psilocybin), and a phosphorylated derivative of 4-hydroxytryptamine.

not val. pub.: Not validly published.

Notched (Adnexed): This term refers to gills which turn towards the cap as in free gills, but they actually do connect to the stipe.

nov.: New.

nov. et: New and.

nrITS Sequences Group: Nuclear Ribosomal Internal Transcribed Spacer sequencing results.

nSLU: Nuclear large ribosomal RNA subunit.

n. sp.: New species.

nSSU: Nuclear small ribosomal RNA subunit.

NTS: Non-Transcribed Spacer Region. Sequences, which are not transcribed, found between transcription units in rDNA. Important sequences that control transcription of the rDNA are within the NTS.

Nucleic Acids: Nucleic acids are large biological molecules essential for all known forms of life. They include DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). Together with proteins, nucleic acids are the most important biological macromolecules; each is found in abundance in all living things, where they function in encoding, transmitting and expressing genetic information. Nucleic acids were discovered by Friedrich Miescher in 1869. The term nucleic acid is the overall name for DNA and RNA. Nucleic acids were named for their initial discovery within the nucleus, and for the presence of phosphate groups (related to phosphoric acid). Although first discovered within the nucleus of eukaryotic cells, nucleic acids are now known to be found in all life forms as well as some nonliving entities, including within bacteria, archaea, mitochondria, chloroplasts, viruses and viroids.The basic component of biological nucleic acids is the nucleotide, each of which contains a pentose sugar (ribose or deoxyribose), a phosphate group, and a nucleobase. Nucleic acids are also generated within the laboratory, through the use of enzymes (DNA and RNA polymerases) and by solid-phase chemical synthesis. The chemical methods also enable the generation of altered nucleic acids that are not found in nature, for example peptide nucleic acids.

Nucleic Acid Hybridization Probe: A fragment of DNA or RNA of variable length (usually 100-1000 bases long) which is used in DNA or RNA samples to detect the presence of nucleotide sequences (the DNA target) that are complementary to the sequence in the probe.

Nucleic Acid Sequence: A nucleic acid sequence is a succession of letters that indicate the order of nucleotides within a DNA (using GACT) or RNA (GACU) molecule. By convention, sequences are usually presented from the 5' end to the 3' end. Because nucleic acids are normally linear (unbranched) polymers, specifying the sequence is equivalent to defining the covalent structure of the entire molecule. For this reason, the nucleic acid sequence is also termed the primary structure.

Nucleobase: Nucleobases are nitrogen-containing biological compounds found within DNA, RNA, nucleotides, and nucleosides. Also termed nitrogenous bases or simply bases, their ability to form base-pairs and to stack upon one another lead directly to the helical structure of DNA and RNA.

Nucleoside: Nucleosides are glycosylamines consisting of a nucleobase (often referred to as simply base)

bound to a ribose or deoxyribose sugar via a beta-glycosidic linkage. Examples of nucleosides include cytidine, uridine, adenosine, guanosine, thymidine and inosine.

Nucleotide (Pl., Nucleotides): Nucleotides are molecules that, when joined, make up the individual structural units of the nucleic acids RNA and DNA. In addition, nucleotides participate in cellular signaling (cGMP and cAMP), and are incorporated into important cofactors of enzymatic reactions.

Nucleotide Sequence: The order in which nucleotides are situated in a chain relative to one another, which in future will provide the template of a particular amino acid, therefore making the order of the nucleotide sequence important.

Nucleus (pl., nuclei): 1. The nucleus is of primary importance in the cell because it is the control center that oversees the metabolic functioning of the cell and ultimately determines the cell's characteristics. Within the nucleus, there are masses of threads called chromatin, which is indistinct in the nondividing cell, but it condenses to chromosomes at the time of cell division. This is where the DNA resides. The nucleolus is the specialized part of chromatin in which the ribosomal RNA (rRNA), is produced. 2. A nucleus (plural nuclei) is a concentrated mass of differentiated protoplasm in cells containing chromosomes and playing an integral role in the reproduction and continuation of genetic material.

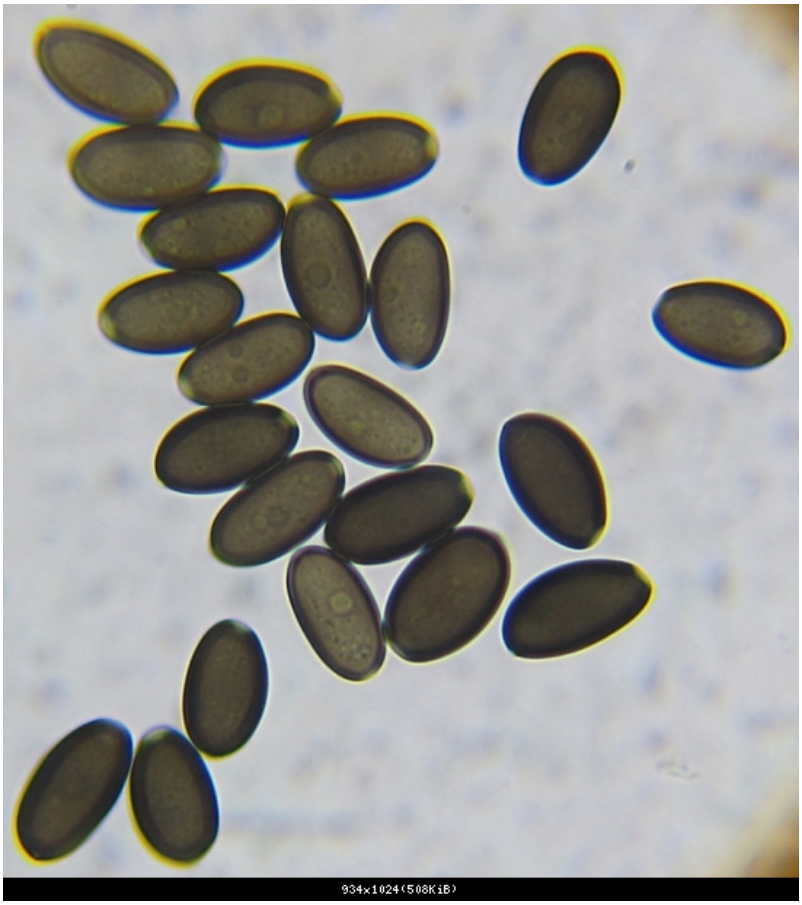
Obclavate: Inversely clavate (inversely club-shaped; claviform).

Obclavate Metuloid: Inversely clavate (inversely club-shaped) cystidium which is not pointed at the end and has thick walls.

Objective: The objective lens of a microscope is the one at the bottom near the sample. At its simplest, it is a very high-powered magnifying glass, with very short focal length. This is brought very close to the specimen being examined so that the light from the specimen comes to a focus inside the microscope tube. The objective itself is usually a cylinder containing one or more lenses that are typically made of glass; its function is to collect light from the sample. Microscope objectives are characterized by two parameters: magnification and numerical aperture. The former typically ranges from 4× to 100×, while the latter ranges from 0.10 to 1.25, corresponding to focal lengths of about 40 to 2 mm, respectively. For high magnification applications, an oil-immersion objective or water-immersion objective has to be used. The objective is specially designed and refractive index matching oil or water must fill the air gap between the front element and the object to allow the numerical aperture to exceed 1, and hence give greater resolution at high magnification. Numerical apertures as high as 1.6 can be achieved with oil immersion. A typical microscope has several objective lenses with different focal lengths screwed into a circular nose piece which may be rotated to select the required lens.

Oblique Germ Pore: The germ pore of a spore having the axis not perpendicular to the base. A germ pore that is oblique will have one of the sides extend up beyone the other (spore on the right) so that if you tried to connect them, it would not be a straight line. Sometimes this difference is subtle.

Below: Oblique germ pore (*Psathyrella atrospora*) courtesy of Byrain



Oblong (Synonymous with cylindrical): 1. Elongated sphere. 2. Spore Q=1.6-2.0. Cystidia Q is greater than or equal to 1.6.

Obovate: Ovate with the larger end in the opposite direction to the usual. Reverse egg-shaped.

Obovoid: Reversely ovoid with the broadest and widest part uppermost.

Obpyriform: Cystidia reversely pyriform, with the broadest and widest part uppermost.

Obtuse: The apex of the cystidia is rounded.

Obtusely-Conical: Pileus conical with rounded apex.

Ocular: Alternative name for an eyepiece.

Oidium (Pl., Oidia): A type of fungal spore (conidium) formed by the breaking up of fungal hyphae into cells, especially as produced by powdery mildews.

Oidiophore: 1. A fungal structure producing oidia. 2. One of the conidia that are borne in chains by certain fungi. 3. A thin-walled spore derived from the fragmentation of a hypha into its component cells.

Oleiferous: 1. Giving rise to oil, as certain seeds or hypha. 2. Although not possessing latex, oleiferous hyphae often possess resinous substances associated with an acrid taste of a mushroom. The hyphae will often turn deep blue in sulfovanilline or brown in sulfoformalin - or black in sulfobenzaldehyde.

Oleocystidia: With oily contents.

Oleiiferous (Oleiferous): Producing oil.

Omphalioid: Characterized by pileus plano-convex to deeply infundibuliform. Lamellae decurrent.

"One Name, One Fungus" (One Fungus = One Name): International Botanical Congress in Melbourne in July 2011 made a change in the International Code of Nomenclature for algae, fungi, and plants and adopted the principle "one fungus, one name." When names are available for both anamorph and teleomorph states of the same fungus, the holomorph either takes the teleomorph name, or it can under some circumstances take the anamorph name if it is subsequently epitypified with a teleomorph. After 1 January 2013, one fungus can only have one name; the system of permitting separate names to be used for anamorphs then ends. This means that all legitimate names proposed for a species, regardless of what stage they are typified by, can serve as the correct name for that species. All names now compete on an equal footing for priority regardless of the stage represented by the name-bearing type. In order not to render names that had been introduced in the past for separate morphs as illegitimate, it was agreed that these should not be treated as superfluous alternative names in the sense of the Code. It was further decided that anamorph-typified names should not be taken up to displace widely used teleomorph-typified names until the case has been considered by the General Committee established by the Congress. Recognizing that there were cases in some groups of fungi where there could be many names that might merit formal retention or rejection, a new provision was introduced. It was decided that lists of names can be submitted to the General Committee and, after due scrutiny, names accepted on those lists are to be treated as conserved over competing synonyms (and listed as Appendices to the Code). Lichen-forming fungi (but not lichenicolous fungi) had always been excluded from the provisions permitting dual nomenclature; the new Code will include a paragraph to make it explicit that lichen-forming fungi are excluded from the newly accepted provisions.

Ontogeny: Ontogeny (also ontogenesis or morphogenesis) is the origin and the development of an organism – for example, from spore to sporocarp. It covers in essence, the study of an organism's lifespan. The word "ontogeny" comes from the Greek ὄντος, ontos, present participle singular of εἶναι, "to be"; and from the suffix -geny, which expresses the concept of "mode of production". In more general terms, ontogeny is defined as the history of structural change in a unity, which can be a cell, an organism, or a society of organisms, without the loss of the organization which allows that unity to exist. More recently, the term ontogeny has been used in cell biology to describe the development of various cell types within an organism. Ontogeny comprises a field of study in disciplines such as developmental biology, developmental psychology, developmental cognitive neuroscience, and developmental psychobiology. Within biology, ontogeny pertains to the developmental history of an organism within its own lifetime, as distinct from phylogeny, which refers to the evolutionary history of species. In practice, writers on evolution often speak of species as "developing" traits or characteristics. This can be misleading. While developmental (i.e., ontogenetic) processes can influence subsequent evolutionary (e.g., phylogenetic) processes (see evolutionary developmental biology), individual organisms develop (ontogeny), while species evolve (phylogeny).

Opaque: Non-translucent.

Operational Taxonomic Units (OTUs): Phylogenetic comparison to other species (usually after DNA studies are performed) and the ordering of each species taxonomically. Typically using rDNA and a percent similarity threshold for classifying microbes within the same, or different, OTUs. A terminal node in phylogenetic analysis. Taxonomic level of sampling selected by the user to be used in a study, such as individuals, populations, species, genera, or strains.

Opisthokonta: A new, super-kingdom combining Kingdom Fungi and Kingdom Animalia. (Sina et al. 2005)

Order: In scientific classification used in biology, the order (Latin: ordo) is a taxonomic rank used in the classification of organisms. Other well-known ranks are life, domain, kingdom, phylum, class, family, genus, and species, with order fitting in between class and family. An immediately higher rank, superorder, may be added directly above order, while suborder would be a lower rank. A taxonomic unit, a taxon, in that rank. In that case the plural is orders (Latin ordines). Example: Walnuts and hickories belong to the family Juglandaceae (or walnut family), which is placed in the order Fagales. What does and does not belong to each order is determined by a taxonomist. Similarly for the question if a particular order should be recognized at all. Often there is no exact agreement, with different taxonomists each taking a different position. There are no hard rules that a taxonomist needs to follow in describing or recognizing an order. Some taxa are accepted almost universally, while others are recognised only rarely.

Orellanine: Orellanine or Orellanin is a mycotoxin found in some mushrooms of the Cortinariaceae family. Structurally, it is a pyridine N-oxide.

Organelles: This term is a general word that describes tiny, microscopic "organs" within a cell. Each type of organelle can serve its own purpose (for instance - nuclei, vacuoles, and mitochondria are all examples of an organelle).

Ornamentation: Some spores have additional features extending from or situated along the cell wall area that can be useful for identification and description. These features are referred to as ornamentation. For example, a species could be described as having an ornamentation consisting of warts or wrinkles.

Ornatocystidia: Thin to thick-walled hyphoid, acute tramal cystidia, covered with two rows of flattened cystidia (Subulicystidium).

Orthorhombic (Synonymous with Prismatic): Of or denoting a crystal system or three-dimensional geometric arrangement having three unequal axes at right angles.

Orthotropic: A spore which is borne centred on the sterigma. Discharge is not forcible. The spores are usually symmetrical. Compare this term to *Heterotropic*.

Ott (J. Ott): Described by Mycologist Jonathan Ott.

OTU (Operational Taxonomic Unit): 1. Taxonomic level of sampling selected by the user to be used in a study, such as individuals, populations, species, genera, or bacterial strains. 2. Operational taxonomic unit, species distinction in microbiology. Typically using rDNA and a percent similarity threshold for classifying microbes within the same, or different, OTUs.

Outgroup: An outgroup is an OTU (Operational Taxonomic Unit) for which external information is available that indicates that the outgroup branched off before all other taxa.

Oval: Having a rounded and slightly elongated outline or shape, like that of an egg.

Ovate: Having an oval outline or ovoid shape, like an egg.

Ovate–Lentiform: Both egg and lens shaped. A combined appearance demonstrating both egg-shape and lens-shape.

Ovoid: Egg-shaped.

Oxidative (Oxidize, Oxidation, Oxidizing): To combine or become combined chemically with oxygen. Redox (reduction-oxidation) reactions include all chemical reactions in which atoms have their oxidation state changed. In general redox reactions involve the transfer of electrons between species. This can be either a simple redox process, such as the oxidation of carbon to yield carbon dioxide (CO 2) or the reduction of carbon by hydrogen to yield methane (CH4), or a complex process such as the oxidation of glucose (C6H12O6) in the human body through a series of complex electron transfer processes.

Ozonium: 1. Form genus of imperfect fungi 2. Orange, shaggy, carpet-like growth somewhat resembling a kind of substitute for mycelium on logs associated with Corprinellus domesticus and Coprinellus radians.

Palisade Layer: With reference to the stipe surface layer, a layer characterized by outgrowths of short hyphae. These hyphae may be cylindrical, clavate, or capitate cells, either in tufts, and may cover a portion or all of the stipe.

Palisadoderm (Synonymous with Palisoderm): 1. With reference to the cortical layer(s), the hyphae are erect, regular or subregular, and not or only moderately inflated. 2. Type of pellis in which terminal elements reach the same level and form a palisade of inflated somewhat elongate cells.

Pallid (Pallide): Very pale in color, almost a dull whitish.

Pantropical (Pan-Tropical): In biogeography, a pantropical ("across the tropics") distribution is one which covers tropical regions of all of the major continents, i.e. in Africa, in Asia and in the Americas.

Papilla: Small, nipple-like protuberance.

Papillate: Covered with papils (a small nipple-shaped projection or elevation).

Paracystidia: Short clavate cells clustered between and among cheilocystidia.

Paraderm (Paraderm Pattern): 1. With reference to the cortical layer(s), the cells are polyhedral, in several layers. 2. A multi-layered pileipellis with cell shapes mostly globose to ellipsoid.

Parafilm: Stretchable material used to seal petri dishes to prevent airborne particles from entering.

Parallel Evolution: Parallel evolution is the development of a similar trait in related, but distinct, species descending from the same ancestor, but from different clades.

Parallel Stipitipellis: The outer tissue of the stem having a parallel pattern.

Parallel Lamellar Hyphae: Another term describing "regular" or parallel Hymenophoral Trama.

Parallel To Subparallel (Synonymous with Regular To Subregular): Refers to hyphae. The hyphae are arranged parallel to one another in which case the hymenophoral trama proper is arranged parallel is said to be parallel (regular). If the hyphae are mostly parallel to one another and slightly intertwined the trama is said to be subparallel (subregular).

Paraphyletic (Paraphyly): Composed of some but not all members descending from a common ancestor. Paraphyly is a term in cladistics. It means a group which does not include all its descendents. Paraphyly is characteristic of some groups of organisms and families, where one separates from other groups at a common origin point. In phylogenetics (a subfield of biology), a group is said to be paraphyletic if it consists of all the descendants of the last common ancestor of the group's members - minus a small number of monophyletic groups of descendants, typically just one or two such groups. Such a group is said to be paraphyletic with respect to the excluded groups. Contrast the term *paraphyletic* with *monophyletic* and *polyphyletic*.

Paraphysis (Pl. Paraphyses): 1. In agarics paraphysis are pavement cells or brachycystidia. 2. Sterile filamentous hyphal end cells composing part of the hymenium. 3. Any of numerous sterile cells occurring between the basidia of basidiomycetous fungi. (See A.H.R. Buller's book *Researches in Fungi Vol. III*here: https://archive.org/details/researchesonfung03bull)

Parasitic Fungi: Parasitic fungi can be distinguished from saprophytic fungi because they grow on and derive their nourishment from *live* tissues of various organisms including humans, animals, insects, and plants. A parasite is an organism that obtains its nutrition from another living organism at that individual's expense. Saprophytic fungi, in comparison, grow on *dead* or *decaying* matter such as woodchips.

Parasitize (Parasitizes, Parasitism): A non-mutual symbiotic relationship between species, where one species, the parasite, benefits at the expense of the other, the host.

Paratype: In systematic botany, a paratype is defined by the International Code of Botanical Nomenclature (ICN/ICBN) as "a specimen cited in the protologue (i.e., the original description) that is neither the holotype nor an isotype, nor one of the syntypes if two or more specimens were simultaneously designated as types" (Art. 9.5). Under this definition, paratypes are not necessarily explicitly identified as such in the original description. Paratypes are useful in that they allow subsequent botanists to know what collections were examined by the original author and considered part of the same taxon in preparing the description of a new taxon, particularly when the holotype and isotypes may be unavailable, of poor quality, or lacking in certain details. Paratypes are also useful in providing one or more collections from which a lectotype may be designated if no holotype, isotype, syntype, or isosyntype is extant (Art. 9.10).

Paravelangiocarpy (Paravelangiocarpous): A type of angiocarpic development of the basidiocarp in which

only a partial veil participates. Having a diminished veil oftentimes lost at maturity.

Parenthosome: A part of septa. A hemispherical perforated cap area between two septa. The perforated parenthosome allows cytoplasmic continuity but prevents the movement of major organelles.

Parietal: Pigment situated in the hyphal wall.

Parsimony: Parsimony implies that simpler hypotheses are preferable to more complicated ones.

Parsimony Informative Characters (PIC): Characters where one character state is observed in at least two sequences and a different character state is observed in at least two others.

Partial Sequence: Not the complete genome sequence, and possibly not even a complete nucleotide sequence within the region being examined.

Partial Veil: In mycology, a partial veil (also called an inner veil, to differentiate it from the "outer" veil, or velum) is a temporary structure of tissue found on the fruiting bodies of some mushrooms. Its role is to isolate and protect the developing spore-producing surface, represented by gills or tubes, found on the lower surface of the cap. A partial veil, in contrast to a universal veil, extends from the stem surface to the cap edge. The partial veil later disintegrates, once the fruiting body has matured and the spores are ready for dispersal. It might then give rise to a stem ring, or fragments attached to the stem or cap edge. In some mushrooms, both a partial veil and a universal veil may be present.

Patches: Fragments of universal veil tissue left on the pileus after it has reached maturity. Patches are similar to warts, but there are fewer of them, and they typically involve larger fragments.

Patent: Hyphae or projections of hyphae perpendicular to surface of stipe.

Pathogenic Fungi: Pathogenic fungi are fungi that cause disease in humans or other organisms. The study of pathogenic fungi is referred to as "medical mycology." Although fungi are eukaryotic organisms, many pathogenic fungi are also microorganisms. Some gilled fungi (mushrooms) are known to be pathogenic to plants, including species in the genus *Armillaria*.

PAUP (Phylogenetic Analysis Using Parsimony): Software to create a phylogenetic tree.

Pavement Cells (Synonymous with Brachycystidia): Brachycystidia in the gills of some species of Coprinus.

PCR: Polymerase chain reaction.

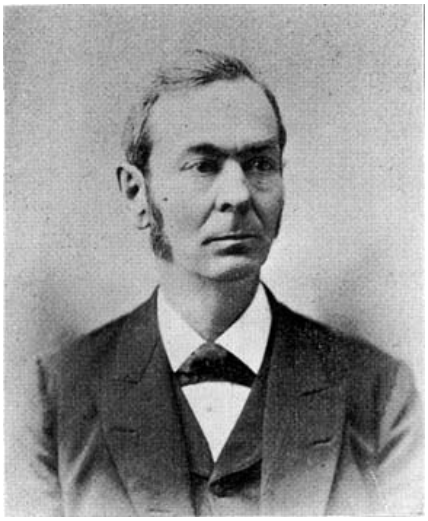
PCR Inhibition (Polymerase Chain Reaction Inhibitors): PCR inhibitors are any factor which prevent the amplification of nucleic acids through the polymerase chain reaction (PCR). PCR inhibition is the most common cause of amplification failure when sufficient copies of DNA are present. PCR inhibitors usually affect PCR through interaction with DNA or interference with the DNA polymerase. Inhibitors can escape removal during the DNA purification procedure by binding directly to single or double-stranded DNA.

PCR Amplification (Polymerase chain reaction amplification/PCR-amplification): The polymerase chain

reaction (PCR) is a biochemical technology in molecular biology to amplify a single or a few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence.

PDAB: In the genus Lyophyllum the lamellae usually turn blue with the application of paradimethylaminobenzaldehyde (PDAB or pDAB). PDAB is a macrochemical known as p-dimethylamino-benzaldehyde composed of PDAB dissolved in solution of conc. HCl acid and 95% ethyl alcohol.

Peck: The standard author abbreviation Peck is used to indicate Charles Horton Peck as the author when citing a species name.



Above: Mycologist and Botanist Charles Peck

Pedicellate: Cystidia provided with a stalk.

Pedunculate: Cystidia provided with a stalk.

Pellicle: 1. An upper surface layer on cap surface that can undergo gelatinization, making the cap viscid (sticky) to the touch; often it can be peeled away from the cap, may be thought of as covering cuticle; same as cuticle or as thinner and more definite. 2. An easily peeling ixocutis.

Pellis (Pl., Pelles) (Synonymous with Skin, Rind, Cuticle): See Pileipellis, Stipitipellis, and Bulbipellis definitions. The outer surface or skin. A pellis can be composed of one to three layers of cell formation: A suprapellis, a mediopellis, and a subpellis.

Peridium: The peridium is the protective layer that encloses a mass of spores in certain fungi. This outer covering is a distinctive feature of the Gasteromycetes.

Peripheral Hyphae: Hyphae located in the outer-most area from the center of a mycelium, or constituting an outer boundary (or periphery) of a mycelium.

Perradial: This term describes the gill plane or pileus plane section being viewed in a gill cross section, in which the long view exposure to the gill (and/or pileus) can be seen. If a gill cross section is laid down on

a microscope slide, the entire macroscopic view is now the perradial view or perradial plane view.

Perispore: A membrane surrounding a spore.

Peronate: Sheathlike; booted.

Perisporium: Refers to layer of a spore's cell wall. The often mucilaginous layer of the basidiospore wall just inside the ectosporium; sometimes early disappearing, sometimes filling the spaces between exosporal ornamentations.

Pers.: The standard author abbreviation Pers. is used to indicate Christiaan Hendrik Persoon as the author when citing a mycological name.

Above: Dr. Christiaan Hendrik Persoon (1761–1836)

Petaloid: Shaped like the petal of a flower (narrowed somewhat at base), similar to spathulate.

Phaeocystidia: Gloeocystidia which are slightly pseudoamyloid and possess brownish contents.

Phaseoliform: Spore shape that shows a concave adaxial side, not parallel to abaxial side.

Phenetic Classification: Classification of organisms based on their overall resemblance to each other.

Phenology: Phenology is the study of periodic plant and animal life cycle events and how these are influenced by seasonal and interannual variations in climate. The word is derived from the Greek φαίνω (phainō), "to show, to bring to light, make to appear" + λόγος (logos), amongst others "study, discourse, reasoning" and indicates that phenology has been principally concerned with the dates of first occurrence of biological events in their annual cycle. Examples include the date of emergence of leaves and flowers, the first flight of butterflies and the first appearance of migratory birds, the date of leaf coloring and fall in deciduous trees, the dates of egg-laying of birds and amphibia, or the timing of the developmental cycles of temperate-zone honey bee colonies. In the scientific literature on ecology, the term is used more generally to indicate the time frame for any seasonal biological phenomena, including the dates of last appearance (e.g., the seasonal phenology of a species may be from April through September).

Because many such phenomena are very sensitive to small variations in climate, especially to temperature, phenological records can be a useful proxy for temperature in historical climatology, especially in the study of climate change and global warming. For example, viticultural records of grape harvests in Europe have been used to reconstruct a record of summer growing season temperatures going back more than 500 years. In addition to providing a longer historical baseline than instrumental measurements, phenological observations provide high temporal resolution of ongoing changes related to global warming.

Phenotype (Phenotypic): 1. The observable constitution of an organism. 2. The appearance of an organism resulting from the interaction of the genotype and the environment.

Phenotypic Plasticity: The ability of an organism to change its phenotype in response to changes in the environment.

Phloxine: Stain used in microscopy. Using a fresh mushroom section, you stain w/phloxine, then you clear the slide with KOH. Also, it is important to get a super-thin section (using a dissecting scope to do this is a huge help) and NOT do a smash mount (crush mt).

Phototropism: Bending towards the light during growth.

Phylogenetic Analysis: The field of phylogenetics makes extensive use of sequence alignments in the construction and interpretation of phylogenetic trees, which are used to classify the evolutionary relationships between homologous genes represented in the genomes of divergent species. The degree to which sequences in a query set differ is qualitatively related to the sequences' evolutionary distance from one another. Roughly speaking, high sequence identity suggests that the sequences in question have a comparatively young most recent common ancestor, while low identity suggests that the divergence is more ancient.

Phylogenetic Convergence: Convergent evolution describes the independent evolution of similar features in species of different lineages. Convergent evolution creates analogous structures that have similar form or function, but were not present in the last common ancestor of those groups. The cladistic term for the same phenomenon is homoplasy, from Greek for same form.

Phylogenetic Divergence: The genetic difference between one species and other species - in relation to a phylogenetic tree with a common ancestor and its descendent species. Divergence (or "evolutionary divergence") occurs at least as a result of an accumulation of differences between reproductive groups (populations of a species) which can lead to the formation of new species. This can occur as a result of genetic drift, natural selection, isolations of populations of a species which reproduce with limited genetic variety, and other methods. With regard to isolated environments and isolated access to tiny amounts of genetic variety, a species decreases its typical genetic variation found within its distinct populations or varieties. This allows different (and long-lasting) characteristics - sometimes substantiating the distinguishment of two or more species. Genetic drift and natural selection are considered primary causes of phylogenetic divergence (and speciation). The opposite of phylogenetic divergence is phylogenetic convergence.

Phylogenetic Family: Upon DNA sequencing (and sometimes without DNA sequencing) the taxonomic

placement of species within the same Family. (Family is above genus and above species).

Phylogenetic Nomenclature: Phylogenetic nomenclature (PN) or phylogenetic taxonomy is an alternative to rank-based nomenclature, applying definitions from cladistics (or phylogenetic systematics). Its two defining features are the use of phylogenetic definitions of biological taxon names, and the lack of obligatory ranks. It is currently not regulated, but the PhyloCode (International Code of Phylogenetic Nomenclature) is intended to regulate it once it is ratified.

Phylogenetic Species Concept (PSC): Monophyly is the centerpiece of the PSC. In other words, the populations of each species should share a common ancestor. A species is the smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent. A species is an irreducible (basal) cluster of organisms, diagnosably distinct from other such clusters, and within which there is a parental pattern of ancestry and descent.

Phylogenetic Tree(s): A phylogenetic tree or evolutionary tree is a branching diagram or "tree" showing the inferred evolutionary relationships among various biological species or other entities based upon similarities and differences in their physical and/or genetic characteristics. The taxa joined together in the tree are implied to have descended from a common ancestor. In a rooted phylogenetic tree, each node with descendants represents the inferred most recent common ancestor of the descendants, and the edge lengths in some trees may be interpreted as time estimates. Each node is called a taxonomic unit. Internal nodes are generally called hypothetical taxonomic units (HTUs) as they cannot be directly observed. Trees are useful in fields of biology such as bioinformatics, systematics and comparative phylogenetics.

Phylogenetics (Phylogenetically): In biology, phylogenetics is the study of evolutionary relation among groups of organisms (e.g. species, populations), which is discovered through molecular sequencing data and morphological data matrices. The term phylogenetics derives from the Greek terms phyle (φυλή) and phylon (φῦλον), denoting "tribe" and "race"; and the term genetikos (γενετικός), denoting "relative to birth", from genesis (γένεσις) "origin" and "birth". Taxonomy, the classification, identification, and naming of organisms, is richly informed by phylogenetics, but remains methodologically and logically distinct. The fields of phylogenetics and taxonomy overlap in the science of phylogenetic systematics — one methodology, cladism (also cladistics) shared derived characters (synapomorphies) used to create ancestor-descendant trees (cladograms) and delimit taxa (clades). In biological systematics as a whole, phylogenetic analyses have become essential in researching the evolutionary tree of life.

Phylogenomic: Phylogenomics is the intersection of the fields of evolution and genomics. The term has been used in multiple ways to refer to analysis that involves genome data and evolutionary reconstructions. It is a group of techniques within the larger fields of phylogenetics and genomics. Phylogenomics draws information by comparing entire genomes, or at least large portions of genomes. Phylogenetics compares and analyzes the sequences of single genes, or a small number of genes, as well as many other types of data.Three major areas fall under phylogenomics: 1. Prediction of gene function 2. Establishment and clarification of evolutionary relationships 3. Prediction and retracing lateral gene transfer.

Phylogeny (Pl., Phylogenies): The study of the evolutionary history of organisms.

Phylogeny Reconstruction: The aim of phylogeny reconstruction is to describe evolutionary relationships of relative recency, connecting common ancestry. These relationships are represented as a branching diagram (tree) with branches. There are different types of trees and a variety of software programs, some of which are free, to reconstruct a phylogenetic relationship.

Phylogeography: The study of the historical processes that may be responsible for the contemporary geographic distributions of individuals. This is accomplished by considering the geographic distribution of individuals in light of the patterns associated with a gene genealogy.

Phylogram: A phylogram is a phylogenetic tree that has branch spans proportional to the amount of character change.

Phylum: A taxonomic rank below kingdom and above class. Traditionally, in botany the term "division" is used instead of "phylum", although in 1993 the International Botanical Congress accepted the designation "phylum". The kingdom Animalia contains approximately 35 phyla; the kingdom Plantae contains 12 phyla. Current research in phylogenetics is uncovering the relationships between phyla, which are contained in larger clades, like Ecdysozoa and Embryophyta.

Physaloamphimitic: This term describes the hyphae pattern as a system of swollen (not standard, unswollen amphimitic hypahe) in which two types of hyphae are seen, namely generative and binding hyphae. See definitions for *generative hyphae* and *binding hyphae*.

Physalodimitic: Dimitic hyphae pattern (displaying both generative and skeletal hyphae) having a swollen appearance throughout the hyphae.

Physalohyphae: Thin to secondary thick-walled hypha with inflated cells.

Physalomitic: Any system in which the hyphal cells inflate; therefore can include physalomonomitic, physalodimitic, physalotrimitic, physaloamphimitic, among other types of inflated hyphal cells.

Physalomonomitic: Monomitic hyphae with swollen cellular pattern. Note: Compare to *monomitic* definition.

Physalopalisadoderm (Physalo-palisadoderm): With reference to the cortical layer(s), the hyphae are erect, regular or subregular, and the hyphal cells are strongly inflated.

Physalotrimitic: Trimitic hyphae (having three patterns - generative, skeletal, and binding/ligative hyphae) but which are also swollen (inflated).

Pigmented (Pigment, Pigmentation): In biology, any substance whose presence in the tissues or cells of animals or plants colors them. The natural coloring of tissue.

Pigmented Encrustations (Pigmented Incrustations): **xyz and zzz** 1. In the cystidia.... 2. In the hyphae.... 3. In the lamellar trama....

Pigmented Inflated Elements: Swollen (comparatively swollen), colored hyphae or hyphae-like cell

material.

Pileal Margin: Synonymous with pileus margin.

Pilei: Plural of pileus. The caps of the mushrooms.

Pileicystidia: Pileus surface possessing longer, stiff, awl-shaped cells.

Pileipellis (Pl., Pileipelles) (Synonymous with Hymenoderm): Pronounced "pie-lee-eh-pellis." The layers constituting the outer surface of the pileus. Corticle layers of pileus. Abbreviated PP or PP.

Pileipellis Cross Section: A section of material cut from the pileus (cap) in which, if the cap were removed from the stipe and laid down on a sheet of paper with the gills facing down, the section would be vertical. Compare to Pileipellis Scalp Section which is a horizontal section from the pileus surface.

Pileipellis Scalp Section: A very thin, small section taken from the surface of the pileus, sometimes at the center, but preferably between the pileus center and the margin. The surface of the pileus is examined in this type of section. To make this section: Use a fresh, sharp razor blade and make two very fine incisions - parallel to one another - about 5mm long. Make a third incision going the opposite direction, creating a U-shape. Grab the loose end using forceps or tweezers that is opposite of the one uncut area of the U. Pull free, tearing the material. Examine the edges under a microscope at low magnification at first.

Pileocystidium (Pl., Pileocystidia) (Not the same as Pilocystidia according to two authors, however many others consider pilocystidia to be identical to pileocystidia): Sterile cell (cystidium) on the surface of the cap, but not including the outer margin (perimeter) of the cap (circumcystidia). Sometimes the hyphae that makes up the pileipellis has ends that are odd in some way and this doesn't make them pileocystdia. Pileocystidia are separate cystidia-like cells. Cystidia located on the pileipellis. Instead of capturing images of pileocystidia, which most mushrooms do not have, you can simply capture the image of the top area of the pileipellis and label it as "pileipellis." In a comparatively few species, single-celled elements stand more or less erect on the pileus surface. These terminal cells, called pileocystidia, are differentiated, and they may be distinguished morphologically from a mere hyphal tip (Source - http://www.mykoweb.com/Pholiota/Basidiocarp.html). Abbreviated "pc".

Pileogloeocystidium (Pl., Pileogloeocystidia): An exudative cystidium on the surface of the pileus.

Pileostipiocarpous (Pileostipitocarpous): A mushroom that has a pileus and stipe.

Pileus (Pl., Pilei): A synonym for cap.

Pileus Cuticle (Synonymous with Cap Cuticle): The covering of the pileus.

Pileus Scalp Section: A very thin, small section taken from the surface of the pileus, sometimes at the center.

Pileitrama (Pileus Trama): This area is located between the pileipellis and the the lamella trama). Hyphae of the pileus trama branch downward to form the hymenophoral trama.

Pileo: Referring to the pileus (cap).

Pilo: Hair-like.

Pilocystidium (Pl., Pilocystidia): Hair on the pileipellis. Some authors define this word as synonymous with Pileocystidia but see Largent & Johnson.

Pilogloeocystidium (Pl., Pilogloeocystidia): A pilogloeocystidium is a hair-like gloeocystidium.

Pilose Agglutination: Hair-like hyphal strand.

Pin-Shaped: Shaped like a bowling pin.

Pip-Shaped: Shaped like an apple seed; sometimes used to describe spores with a plage at one end that would be described as elliptic by other authors.

Pisiform: Pea-shaped.

Pithy: Soft or spongy tissue.

Pitted: With small depressions.

Plage: A distinctive flattened area on the dorsal side of the spore (the side facing the central axis of the basidium on which the spore develops), near the hilar appendage (the part of the spore that was attached to the basidium), also known as suprahilar disc; if plage amyloid it is known as a hilar spot, if depressed as suprahilar depression.

Plagiotrichoderm: Pileipellis trichoderm with elements curving upward and perpendicular to the surface.

Plagiotrichoderm Tomentum: With reference to the cortical layer(s), a thick, loose, wooly layer. Basal hyphae are repent while most terminal hyphae are obliquely ascending. All hyphae are irregularly arranged.

Plan Achromat or Plan Objective: Distortion or curvature at the edge of the field is a common optical defect in inexpensive objectives. This does not necessarily limit their usefulness for visual observation, but for photography it is a significant flaw and will produce out of focus images at the edge of the field. Higher grade objectives are available which correct this shortcoming. Flatfield objectives are flat across 70-85% of the field of view, while Plan objectives are flat across 90-100% of the field of view.

Plano-Concave: Pileus slightly concave.

Plano-Convex: Pileus slightly convex.

Plasma Membrane: The cell membrane or plasma membrane is a biological membrane that separates the interior of all cells from the outside environment. The cell membrane is selectively permeable to ions and

organic molecules and controls the movement of substances in and out of cells. It basically protects the cell from outside forces. It consists of the lipid bilayer with embedded proteins. Cell membranes are involved in a variety of cellular processes such as cell adhesion, ion conductivity and cell signaling and serve as the attachment surface for several extracellular structures, including the cell wall, glycocalyx, and intracellular cytoskeleton.

Plasmogamy: Plasmogamy is a stage in the sexual reproduction of fungi. In this stage, the cytoplasm of two parent mycelia fuse together without the fusion of nuclei, as occurs in higher terrestrial fungi. After plasmogamy occurs, the secondary mycelium forms. The secondary mycelium consists of dikaryotic cells, one nucleus from each of the parent mycelia. It is the fusion of protoplasm between two motile or non-motile gametes. It involves the union of two protoplast bringing two haploid nuclei close together in the same cell.

Plasmolysis: Plasmolysis is the process in which cells lose water in a hypertonic solution. The reverse process, cytolysis, can occur if the cell is in a hypotonic solution resulting in a lower external osmotic pressure and a net flow of water into the cell. Through observation of plasmolysis and deplasmolysis it is possible to determine the tonicity of the cell's environment as well as the rate solute molecules cross the cellular membrane.

Plectology: Histology for fungi. Tissue science for mushrooms and all fungi.

Pleomorphic: The occurrence of two or more structural forms during a life cycle.

Plectenchyma: This term is used to describe organized fungal tissues. It means, literally, to weave with infusion - an intimately woven tissue. Two types of plectenchyma are described: Prosenchyma (approaching or almost a tissue), and pseudoparenchyma (meaning a false plant tissue or resembling plant tissue).

Pleurocystidium (pl., pleurocystidia): Pleurocystidia can closely resemble the appearance of a particular mushroom's cheilocystidia. Pleurocytidia occur within the gill - not along the true gill edge. By cutting into the gill pleurocystidia can been seen on the "false gill edges." They are usually far less numbered and more spaced out than cheilocystidia. Not all gilled mushrooms possess pleurocystidia.

Pleurochrysocystidia: Chrysocystidia that are not found along the true gill edge(s) but rather upon the gill face and away from the true gill edge. These cells are generally identified based on having a yellow or golden body (or body part), that becomes more deeply yellow when exposed to KOH, ammonia or other alkaline compounds.

Pleuromacrocystidia: Posessing very large pleurocystidia cells throughout the gill tissue.

Pleuropseudocystidium (pl., pleuropseudocystidia): Pseudocystidium located on the face (side) of a gill.

Pleurotoid: Characterized by stipe absent or lateral.

Plicate: Pileus folded radially like a fan.

Pluristratous Cellular Suprapellis (Synonymous with Epithelium and Polycystoderm):

Pluteaceae: The Pluteaceae are a family of small to medium-sized mushrooms which have free gill attachment and pink spores. Members of Pluteaceae can be mistaken for members of Entolomatacae but can be distinguished by their angled spores and attached gills. The four genera in the Pluteaceae include the widely distributed Volvariella and Pluteus, the rare Chamaeota, and Volvopluteus, newly described in 2011 as a result of molecular analysis. The Dictionary of the Fungi (10th edition, 2008) estimates there are 364 species in the family.

Pluteoid: Characterized by lamellae being free; context of pileus discontinuous wit context of stipe; stipe usually longer than diameter of pileus.

Polycystoderm (Synonymous with Epithelium): Pluristratous cellular supra-pellis.

Polygonal: Having many sides or relating to a surface marked by polygons; "polygonal structure".

Polymerase Chain Reaction (PCR): A biochemical technology in molecular biology to amplify a single or a few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence.

Polymorphous: Having, assuming, or occurring in various forms.

Polymorphism (Polymorphic): The existence of two or more forms of individuals within the same species.

Polyphasic: Having more than one phase in a study. For instance, a study of chemotaxonomy, molecular phylogeny, and generic affinities of a particular set of species.

Polyphyletic (Polyphyly): (Greek for "of many races") Relating to or characterized by descent from more than one ancestral group. A polyphyletic group is a group whose members' last common ancestor is not a member of the group. Polyphyly is a term in cladistics. It describes a group of organisms whose last common ancestor is not a member of the group. Another way of expressing this is to say that polyphyly includes groups some members of which are descended from ancestral populations.

Polyporaceae: The Polyporaceae are a family of bracket fungi belonging to the Basidiomycota. The flesh of their fruiting bodies varies from soft to very tough. Most members of this family have their hymenium (fertile layer) in vertical pores on the underside of the caps, but some of them have gills (e.g. Panus) or gill-like structures (such as Daedaleopsis, whose elongated pores form a corky labyrinth). Many species are brackets, but others have a definite stipe - for example: *Polyporus badius*. Most of these fungi have white spore powder but members of the genus *Abundisporus* have colored spores and produce yellowish spore prints. Cystidia are absent.

Polysaccharide: Polysaccharides are long carbohydrate molecules of monosaccharide units joined together by glycosidic bonds.

Polytypic Species: Polytypic indicates a separate description (and type specimen) is needed for each of the distinct populations, instead of one for the entire species.

Pore: A circular depression on the spores of many species. See germ pore.

Poroid: Pore-like; poriform. Resembling a pore, or small puncture.

Porous Septa: Hyphae cells that are septate and contain pores that act as a pathways for the exchange of organelles or nuclei from one hypha to the next.

Positional Cloning (Genetic Screen): A genetic screen is an experimental technique used to identify and select for individuals who possess a phenotype of interest in a mutagenized population. Hence a genetic screen is a type of phenotypic screen. Genetic screens can provide important information on gene function as well as the molecular events that underlie a biological process or pathway. While genome projects have identified an extensive inventory of genes in many different organisms, genetic screens can provide valuable insight as to how those genes function.

p.p.: Pro parte. For part. Synonymy with another taxon.

Praticolous: Fungi which parasitize the roots of grasses and herbs.

Precipitates: A section that has been broken up into pieces. A solution that has caused a solid substance to be separated.

Precipitation: In chemistry and particularly in regard to microscopy, precipitation is the alteration of a liquid solution (usually a mounting or staining agent) into a hardened form. This can be caused by a chemical reaction inducing the hardening of one or more chemicals. A chemical can also precipitate from a fully liquid form into a gradually hardening form as it dries and becomes more and more dense. Precipitation is the creation of a solid in a solution or inside another solid during a chemical reaction or by diffusion in a solid. When the reaction occurs in a liquid solution, the solid formed is called the 'precipitate'. The chemical that causes the solid to form is called the 'precipitant.' A common example of precipitation occurs when KOH begins drying and forms crystals on the glass slide.

Pre-Crystalline Matrix (PCM, Precrystalline Matrix): The putative build-up of calcium and oxalic acid between the wall layers of cystidia prior to calcium-oxalate crystal formation. Crystals appear to form basipetally from this matrix.

Precursor mRNA (pre-mRNA): An immature single strand of messenger ribonucleic acid (mRNA). pre-mRNA is synthesized from a DNA template in the cell nucleus by transcription. Pre-mRNA comprises the bulk of heterogeneous nuclear RNA (hnRNA). The term hnRNA is often used as a synonym for pre-mRNA, although, in the strict sense, hnRNA may include nuclear RNA transcripts that do not end up as cytoplasmic mRNA. Once pre-mRNA has been completely processed, it is termed "mature messenger RNA", "mature mRNA", or simply "mRNA".

Preparate Cut-Out: A section of the inside of a mushroom that can be obtained by removing a whole gill from a mushroom and trimming the left and right sides off. The cheilocystidia (if present) will be located on the true gill edge (bottom area of the section). The pleurocystidia (if present) can be viewed along the left and right sides and within the gill. The pilleipellis can be viewed at the top area of the section. In

mushrooms which have rather small gills compared to their large pileus tissue, a single mushroom can be cut in half, then into quarters. As if one were carving letters into the mushroom, a section that will include the entire pileus area along with gill material can be made. See image below of a common Agaricus species.

Primary Angiocarpy: a type of angiocarpic development in which the primordial hymenium is initiated in a closed cavity.

Primary Decomposer: (Compare to Secondary Decomposer, Tertiary Decomposer, and Intermediate Decomposer) Primary decomposers are the first to show up and thrive in the decomposition process, allowing for secondary decomposers (often other types of fungi) to eventually begin a new phase of breaking down material such as wood chips.

Primary Mycelium: The uninucleate mycelium produced by a germinating basidiospore. (Compare to "Secondary Mycelium").

Primary Species Criterion (Primary Species Criteria): The primary defining property of species (which is dependent at the moment upon the mycologist(s) and the taxonomic method(s) used to identify a collection to species level).

Primer (Including Forward Primer and Reverse Primer): A primer is a strand of nucleic acid that serves as a starting point for DNA synthesis. They are required for DNA replication because the enzymes that catalyze this process, DNA polymerases, can only add new nucleotides to an existing strand of DNA. The polymerase starts replication at the 3'-end of the primer, and copies the opposite strand. In most cases of natural DNA replication, the primer for DNA synthesis and replication is a short strand of RNA (which can be made de novo). Many of the laboratory techniques of biochemistry and molecular biology that involve DNA polymerase, such as DNA sequencing and the polymerase chain reaction (PCR), require DNA primers. These primers are usually short, chemically synthesized oligonucleotides, with a length of about twenty bases. They are hybridized to a target DNA, which is then copied by the polymerase.

Primer Pair: A primer is a short, single-stranded DNA sequence used in the polymerase chain reaction (PCR) technique. In the PCR method, a pair of primers is used to hybridize with the sample DNA and define the region of the DNA that will be amplified.

Primordium (Pl. Primordia): A very young, not fully differentiated basidiocarp (newly developing mushroom).

Prismatic: (Synonymous with Orthorhombic): Of or denoting a crystal system or three-dimensional geometric arrangement having three unequal axes at right angles.

Projectile-Shaped (Synonymous with Bullet-Shaped): Shaped like a bullet.

Protoplasm: Protoplasm is the living contents of a cell that is surrounded by a plasma membrane. Protoplasm is composed of a mixture of small molecules such as ions, amino acids, monosaccharides and water, and macromolecules such as nucleic acids, proteins, lipids and polysaccharides.

Protuberant: Sticking out from a surface. Protruding, projecting, prominent, jutting, overhanging, proud, bulging.

Proximal (Proximal End): End of spore attached nearest to the basidium. The base. A larger, more generalized area than just the apiculus (hilar appendage).

Pruinose (Synonymous with Pruinate): Looking finely powdered or finely granular, often due to cystidia projecting from surface.

Pruniform: Plum-shaped; having the appearance of a plum.

Pseudoamyloid (Synonymous with Dextrinoid): In mycology the term amyloid refers to a crude chemical test using iodine in either Melzer's reagent or Lugol's solution, to produce a black to blue-black positive reaction.

Pseudoangiocarpy: Synonymous with secondary angiocarpy.

Pseudocystidium (Pl., Pseudocystidia) (Synonymous with Macrocystidia): 1. Differentiated prolongation of vascular hypha into the hymenium. 2. Gloeocystidia which are tramal in origin and project into and usually beyond the hymenium or the surface of the pileus or stipe. Pseudocystidia are usually metachromatic in Cresyl Blue. They also stain in the acid-aldehydes; black in sulfobenzaldehyde or red in chlorovanillin and brown in sulfoformol. 3. Extensions of conducting system, (eg. gloeocystidia, chrysocystidia, phaeocystidia, and macrocystidia).

Pseudofleshy (Pseudo-Fleshy): A little flesh-like (fleshy).

Pseudohyphae: Distinguished from true hyphae by their method of growth, relative frailty and lack of cytoplasmic connection between the cells. They are the result of a sort of incomplete budding where the cells remain attached after division.

Pseudoparaphysis (Pl., Pseudoparaphyses): Elements found in certain gilled mushrooms that are similar to the paraphyses found as sterile elements among the asci on spore bearing surfaces of ascomycetes

Pseudoparenchyma(-tous): The tissue of a primordial agaric where no differentiation has taken place.

Pseudoparenchymatous: Cells that appear isodiametric in shape.

Pseudophysis(-es) (Synonymous with Pavement Cells or Brachycystidia in agarics): A type of leptocystidia - cells shaped like a stone walkway more or less. Found in Coprinus species.

Pseudoryhiza: A root-like extension developed at the base of the stem.

Pseudostipe (Synonymous With Pseudo-Stipitate and Pseudostipitate): Having an almost stem-like appearance but not considered a stem. See *Lycoperdum lividiim*, *Lysurus mokusin*, *Pleurotus calyptratus*, and *Scleroderma verrucosum*, images for visual comparison.

Psilocin (Synonymous With Psilocine): Psilocin (also known as 4-OH-DMT, psilocine, psilocyn, or psilotsin), is a substituted tryptamine alkaloid and a serotonergic psychedelic substance. It is present in most psychedelic mushrooms together with its phosphorylated counterpart psilocybin. Psilocin is a Schedule I drug under the Convention on Psychotropic Substances.[2] The mind-altering effects of psilocin are highly variable and subjective and resemble those of LSD and DMT. Psilocin and its phosphorylated cousin, psilocybin, were first isolated and named in 1958 by Swiss chemist Albert Hofmann. Hofmann obtained the chemicals from laboratory-grown specimens of the entheogenic mushroom Psilocybe mexicana.

Psilocybe: *Psilocybe* (pronounced sigh-loh-sib-ee) is a genus of gilled fungi (mushrooms) in the order *Agaricales* and the Family *Strophariaceae*. The first species of *Psilocybe* was described under the name *Agaricus semilanceatus* by Mycologist Elias Magnus Fries in 1838 (see Epicrisis Systematis Mycologici, p. 231). Decades later, in 1871, taxonomic discernment by Minister Paul Kummer (see Der Führer in die Pilzkunde (in German) (1 ed.). Zerbst, Germany: C. Luppe. p. 71.) led to the genus and species epithet *Psilocybe semilanceata*. *Psilocybe semilanceata* is therefore the type species of this genus. This genus contains over 100 taxa using current identification methods, although comparative studies are still pending as of 2014, including full genomic comparison and mating studies. The leading experts of this genus are currently Dr. Gastón Guzmán and Alan Rockefeller. An updated monograph is anticipated of *The genus Psilocybe: A systematic revision of the known species including the history, distribution, and chemistry of the hallucinogenic species*, amending the older 1983 version.

Below: Spores courtesy DIC microscopy by Alan Rockefeller from the most widely known *Psilocybe* species, *Psilocybe cubensis* (pronounced sigh-loh-sib-ee cue-ben-sis). The type species originating this genus is *Psilocybe semilanceata* (spores seen second image down courtesy zzz).

Psilocybin (Synonymous With Psilocybine): Psilocybin is a naturally occurring psychedelic compound produced by more than 200 species of mushrooms, collectively known as psilocybin mushrooms. The most potent are members of the genus Psilocybe, such as P. azurescens, P. semilanceata, and P. cyanescens, but psilocybin has also been isolated from about a dozen other genera. As a pro-drug, psilocybin is quickly converted by the body to psilocin, which has mind-altering effects similar (in some aspects) to those of LSD, mescaline, and DMT. The effects generally include euphoria, visual and mental hallucinations, changes in perception, a distorted sense of time, and spiritual experiences, and can include possible adverse reactions such as nausea and panic attacks.

Psychedelic: A psychedelic substance is a psychoactive drug whose primary action is to alter cognition and perception. Psychedelics are part of a wider class of psychoactive drugs known as hallucinogens, a class that also includes structurally unrelated substances such as dissociatives and deliriants. Unlike other drugs such as stimulants and opioids which induce familiar states of consciousness, psychedelics tend to affect and explore the mind in ways that result in the experience being qualitatively different from those of ordinary consciousness. The psychedelic experience is often compared to non-ordinary forms of consciousness such as trance, meditation, yoga, religious ecstasy, dreaming and even near-death experiences. With a few exceptions, most psychedelic drugs fall into one of the three following families of chemical compounds; tryptamines [more specifically: alkylated tryptamines], phenethylamines [more specifically: alkoxylated phenethylamines], and lysergamides.

Pterate (Synonymous with Alate): 1. Having wings; winged. 2. Having membranous expansions like wings. 3. Spore ornamentation has ridges that are so large that they appear wing-like.

Pubescent (Synonymous with Downy): The pileus or stipe is covered with short, soft, fine hairs.

Pulverulent: Covered with powder.

Punctate (Punctate-Roughened): 1. Spore ornamentation describing outgrowths so minute that they appear almost non-existent, but they are equidistant ornamentations. 2. Marked with dots consisting of hollows, depressions, spots, raised-joined scales, or agglutinated fibrils, all very small.

Putrescent: Undergoing the process of decay; rotting.

Pyriform (Synonymous with Sublimoniform and Piriform): Pear-shaped.

Q: Quotient of length and width or breadth.

Qav: Average quotient.

Quiescent: Inactive or in repose; tranquilly at rest. Dormant and not fruiting or active but capable when the right conditions present themselves.

Q-values: Quotient values presented as minimum, lower quartile, upper quartile and maximum, respectively.

Quadrangular: Spores shaped like a rectangle or square.

Quadrate: Being square or approximately square. This term is occasionally used to describe a spore shape.

Quaternary Gills: The fourth and smallest (or lowest) gill in a pattern of gill sizes repeating from primary (largest), secondary, tertiary, and quaternary.

Quotient (Abbreviated to "Q"): Length divided by width. Typically this is done when measuring spores, but

not when measuring cystidia. Usually applied to basidiospores to
indicate how broad or narrow are. This statistic is helpful in determining a specific shape (e.g. globose, subglobose, broadly ellipsoid, etc).

Radial Section (Radial Gill Cross Section): A radial section is one of two types of *gill cross sections*. This type of section begins from any point of the margin of the cap and reaches the opposing side after first cutting through the center of the cap. It differs from a tangential section because a radial section must travel thru the center point of the pileus.

Radially Rimose: Cap surface marked with numerous, superficial, radial clefts or cracks.

Radially Symmetrical Spores: Spores that are basically perfectly circular so that any radius measurement take is identical within a given spore.

Radiatus: Provided with spokes or rays. (Radiatus may refer to a radially striped pileus when dried).

Rameales-Structure: Pileipellis with irregularly shaped and arranged, nodose, or en bosse, or diverticulate elements.

rDNA (Synonymous with Nuclear rDNA and Nuclear Ribosomal DNA): Spliced dNA formed from two or more different sources that have been cleaved by restriction enzymes and joined by ligases. Genetically engineered dna made by recombining fragments of dna from different organisms.The joining together of genetic material from two different organisms.

Reagent: A substance used in a chemical reaction to detect, measure, examine, or produce other substances. A substance or mixture formula for use in chemical analysis or other reactions. A substance or compound that is added to a system in order to bring about a chemical reaction, or added to see if a reaction occurs. Although the terms reactant and reagent are often used interchangeably, a reactant is more specifically a substance that is consumed in the course of a chemical reaction. Solvents, although they are involved in the reaction, are usually not referred to as reactants. Similarly, catalysts are not consumed by the reaction, so are not described as reactants. In organic chemistry, reagents are compounds or mixtures, usually composed of inorganic or small organic molecules, that are used to effect a transformation on an organic substrate. Examples of organic reagents include the Collins reagent, Fenton's reagent, and Grignard reagent. There are also analytical reagents which are used to confirm the presence of another substance. Examples of these are Fehling's reagent, Millon's reagent and Tollens' reagent. When purchasing or preparing chemicals, reagent-grade describes chemical substances of sufficient purity for use in chemical analysis, chemical reactions or physical testing.

Recombination: The rearrangement of genetic material, especially by crossing over in chromosomes or by the artificial joining of segments of DNA from different organisms. The natural formation in offspring of genetic combinations not present in parents through the processes of crossing over or independent assortment.

Rectocutis: 1. A trichoderm pileipellis. 2. With reference to the cortical layer(s), the hyphae pattern is regular, subparallel, inflated or not, and often radially arranged.

Redhead: The author name Redhead is used to note Scott Redhead as the author when describing a mycological species.

Reduced (In reference to the stem): Stipe is very short.

Reflexed: Margin of pileus bent upwards.

Refraction: In microscopy, refraction occurs when the light waves pass between the medium and the specimen, causing blurring and distortion of the image. Differences in refractive index between materials causes the light to bend as it passes between them. The "refractive index" of a material is a measure to the degree that light is bent (refracted) by passing through the material.

Refractive Contents: Any unidentified mass within a cell that possess the capacity to deflect light from a straight path by refraction.

Refractive Pigment-Body: Any pigmented tissue possessing the ability to deflect light.

Refringent Content(s): Any contents within a cell producing refraction; refractive.

Regular: Hymenophoral trama having parallel hyphae.

Regular Epithelium: An epithelium made up of elements in erect rows.

Reniform: Kidney-shaped.

Repent: Hyphae creeping and not ascending.

Resting spore: A resting spore is a spore created by fungi which is thickly encysted (has a thick cell wall) in order to survive through stressful times, such as drought. It protects the spore from biotic (microbial, fungal viral), as well as abiotic (wind, heat, xeric conditions) factors.

Restriction Enzyme: A restriction enzyme (or restriction endonuclease) is an enzyme that cuts DNA at specific recognition nucleotide sequences known as restriction sites. Restriction enzymes are commonly classified into three types, which differ in their structure and whether they cut their DNA substrate at their recognition site, or if the recognition and cleavage sites are separate from one another. To cut DNA, all restriction enzymes make two incisions, once through each sugar-phosphate backbone (i.e. each strand) of the DNA double helix. These enzymes are found in bacteria and archaea and probably evolved to provide a defense mechanism against invading viruses.Inside a bacteria, the restriction enzymes selectively cut up foreign DNA in a process called restriction; while host DNA is protected by a modification enzyme (a methylase) that modifies the bacterial DNA and blocks cleavage. Together, these two processes form the restriction modification system.

Restriction Fragment: A restriction fragment is a DNA fragment resulting from the cutting of a DNA strand by a restriction enzyme (restriction endonucleases), a process called restriction. Each restriction enzyme is highly specific, recognising a particular short DNA sequence, or restriction site, and cutting both DNA strands at specific points within this site.

Restriction Fragment Analysis: The basic technique for detecting RFLPs involves fragmenting a sample of DNA by a restriction enzyme, which can recognize and cut DNA wherever a specific short sequence occurs, in a process known as a restriction digest. The resulting DNA fragments are then separated by length through a process known as agarose gel electrophoresis, and transferred to a membrane via the Southern blot procedure. Hybridization of the membrane to a labeled DNA probe then determines the length of the fragments which are complementary to the probe. An RFLP occurs when the length of a detected fragment varies between individuals. Each fragment length is considered an allele, and can be used in genetic analysis. RFLP analysis may be subdivided into single- (SLP) and multi-locus probe (MLP) paradigms. Usually, the SLP method is preferred over MLP because it is more sensitive, easier to interpret and capable of analyzing mixed-DNA samples.[citation needed] Moreover, data can be generated even when the DNA is degraded.

Reticulate: Covered with a network of interlacing lines.

Reticulately Venose: Pileus surface marked with anastomosing veins forming angular patches.

Revolute: Margin of pileus rolled back.

RFLP: In molecular biology, restriction fragment length polymorphism, or RFLP (commonly pronounced “rif-lip”), is a technique that exploits variations in homologous DNA sequences. It refers to a difference between samples of homologous DNA molecules that come from differing locations of restriction enzyme sites, and to a related laboratory technique by which these segments can be illustrated. In RFLP analysis, the DNA sample is broken into pieces (digested) by restriction enzymes and the resulting restriction fragments are separated according to their lengths by gel electrophoresis. Although now largely obsolete due to the rise of inexpensive DNA sequencing technologies, RFLP analysis was the first DNA profiling technique inexpensive enough to see widespread application.

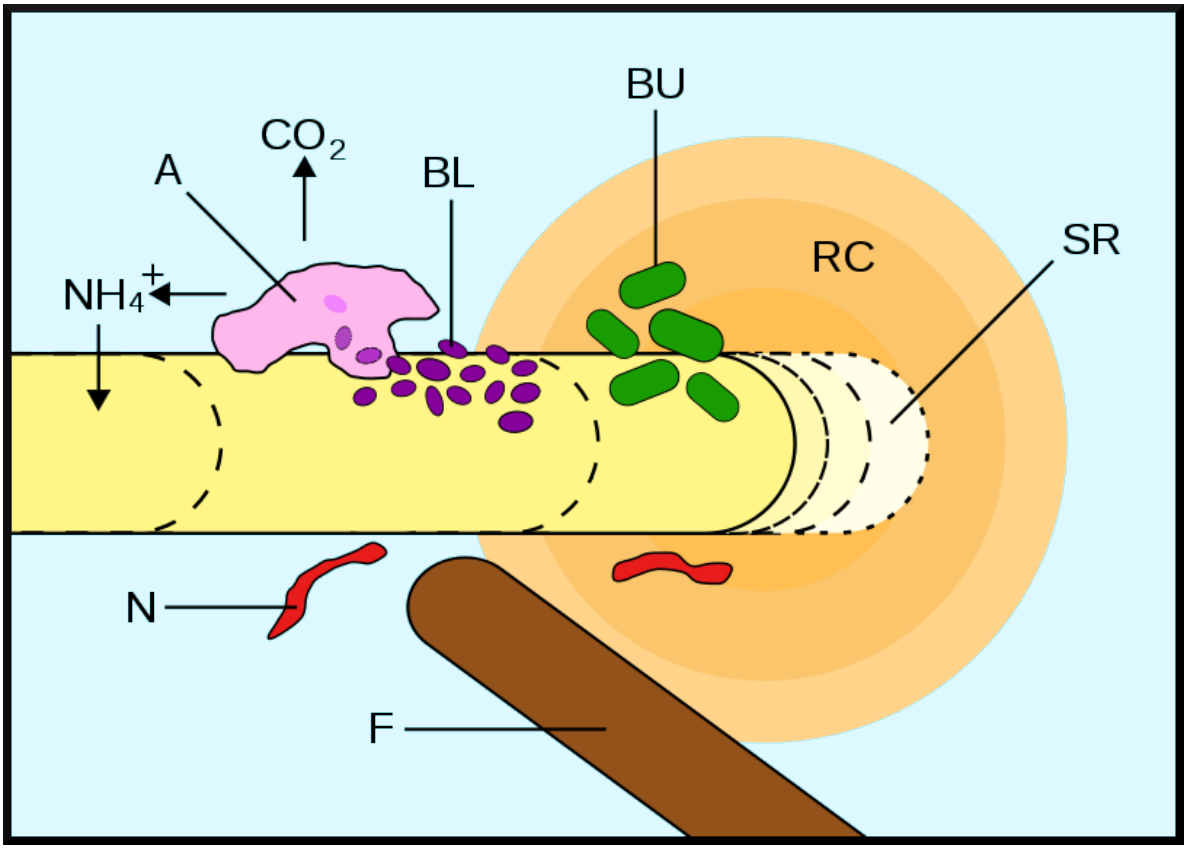
Rhizal: Roots.

Rhizoid (Pl., Rhizoids): Root-like structure from the base of fruiting body.

Rhizomorph: A visible root-like mycelial strand. Rhizomorphs can be contrasted with mycelial fans.

Rhizosphere: The rhizosphere is the narrow region of soil that is directly influenced by root secretions and associated soil microorganisms. Soil which is not part of the rhizosphere is known as bulk soil. The rhizosphere contains many bacteria that feed on sloughed-off plant cells, termed rhizodeposition, and the proteins and sugars released by roots. Protozoa and nematodes that graze on bacteria are also more abundant in the rhizosphere. Thus, much of the nutrient cycling and disease suppression needed by plants occurs immediately adjacent to roots. Plants secrete many compounds into the rhizosphere which serve different functions. Strigolactones, secreted and detected by mycorhizal fungi, stimulate the germination of spores and initiate changes in the mycorhiza that allow it to colonize the root. The parasitic plant, Striga also detects the presence of strigolactones and will germinate when it detects them; they will then move into the root, feeding off the nutrients present. Symbiotic Nitrogen-fixing bacteria, such as Rhizobium species, detect compounds like flavonoids secreted by the roots of leguminous plants and then produce nod factors which signal to the plant that they are present and will lead to the formation of root

nodules. In these nodules bacteria, sustained by nutrients from the plant, convert nitrogen gas to a form that can be used by the plant. Non-symbiotic (or "free-living") nitrogen-fixing bacteria may reside in the rhizosphere just outside the roots of certain plants (including many grasses), and similarly "fix" nitrogen gas in the nutrient-rich plant rhizosphere. Even though these organisms are thought to be only loosely associated with plants they inhabit, they may respond very strongly to the status of the plants.



Above: The rhizosphere courtesy Wikimedia Commons. **Key:** A = Amoeba consuming bacteria. BL = Energy-limited bacteria. BU = Non-energy-limited bacteria. RC = Root-derived carbon. SR = Sloughed-root hair cells. F = Fungal hyphae. N = Nematode worm.

Rhombic: A 4-sided flat shape with straight sides where all sides have equal length.

Rhomboid: Leaf shaped like a parallelogram with adjacent sides of unequal length.

Rhombus: An outline with four equal sides, but with angles that are not right angles.

RI Value (RI Values): 1. PAUP Retention Index Value.

Ribbed Spores (Synoymous with Subalate Spores): Having a pattern of raised bands.

Ribonucleic Acid: (RNA) Ribonucleic acid is a ubiquitous family of large biological molecules that perform multiple vital roles in the coding, decoding, regulation, and expression of genes.

Ribosomal DNA (rDNA): Ribosomal DNA (rDNA) is a DNA sequence that codes for ribosomal RNA. Ribosomes are assemblies of proteins and rRNA molecules that translate mRNA molecules to produce proteins. rDNA is short for ribosomal DNA, coding for the ribosomal RNA found in the mitochondrion.

Ribosomal Nuclear DNA (Nuclear Ribosomal DNA, nrDNA): nrDNA refers to nuclear ribosomal RNA in order to distinguish it from the ribosomal RNA found in the mitochondrion.

Ribosomal Sequences: Ribosomal DNA (rDNA) sequences are DNA sequences that code for ribosomal RNA. Ribosomes are assemblies of proteins and rRNA molecules that translate mRNA molecules to produce proteins.

Ridged: Spores with narrow raised straight or curved strips on the surface of the spore.

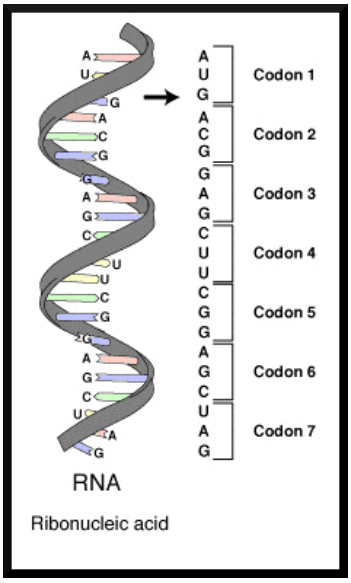
Rimose: Cracked, referring to surface of cap or stem.

Rimulose: Pileus surface minutely rimose.

Rind: Outer surface of the stipe. "Approximately" equal to the stipitipellis.

Riparian Zone (Riparian Habitat): A riparian zone or riparian area is the interface between land and a river or stream. Riparian is also the proper nomenclature for one of the fifteen terrestrial biomes of the earth. Plant habitats and communities along the river margins and banks are called riparian vegetation, characterized by hydrophilic plants. Riparian zones are significant in ecology, environmental management, and civil engineering because of their role in soil conservation, their habitat biodiversity, and the influence they have on fauna and aquatic ecosystems, including grassland, woodland, wetland or even non-vegetative. In some regions the terms riparian woodland, riparian forest, riparian buffer zone, or riparian strip are used to characterize a riparian zone. The word "riparian" is derived from Latin ripa, meaning river bank.

RNA: Ribonucleic acid /raɪbə.njuːˌkleɪ.ɨk ˈæsɪd/, or RNA, is part of a group of molecules known as the nucleic acids, which are one of the four major macromolecules (along with lipids, carbohydrates and proteins) essential for all known forms of life. Like DNA, RNA is made up of a long chain of components called nucleotides. Each nucleotide consists of a nucleobase, a ribose sugar, and a phosphate group. The sequence of nucleotides allows RNA to encode genetic information. All cellular organisms use messenger RNA (mRNA) to carry the genetic information that directs the synthesis of proteins.



RNA Polymerase II: RNA polymerase II (also called RNAP II and Pol II) is an enzyme found in eukaryotic cells. It catalyzes the transcription of DNA to synthesize precursors of mRNA and most snRNA and microRNA. The purified enzyme has subunits (regions) that mycologists compare and study.

RNA Splicing: Modification of the nascent pre-mRNA taking place after or concurrently with its transcription, in which introns are removed and exons are joined. This is needed for the typical eukaryotic messenger RNA before it can be used to produce a correct protein through translation. For many eukaryotic introns, splicing is done in a series of reactions which are catalyzed by the spliceosome, a complex of small nuclear ribonucleoproteins (snRNPs), but there are also self-splicing introns.

RNA Transcript (RNA Transcripts): RNA transcribed in the nucleus.

Roman-Aqueduct-Reminiscent Section (Roman Aqueduct Section): Synonymous with a gill cross section.

Rough Spores: Spores with strongly punctate surfaces. (Punctate = Studded with or denoting dots or tiny holes).

Rostrate (Synonymous with Rostellate): With a beak; of cystidia, having a beak-like or finger-like protuberance called a rostrum.

Rostrulate: Provided with a beak-shape.

Rostrum: Apex of a restrate cystidium. A beak-like or finger-like protuberance.

Rounded Flabelliform: Pileus rounded and fan-shaped.

Rounded Triangular: Spores three-angled.

RPB2: The second largest RNA polymerase subunit. A protein-coding gene.

rRNA: In molecular biology, ribosomal ribonucleic acid (rRNA) is the RNA component of the ribosome, and

is essential for protein synthesis in all living organisms. It constitutes the predominant material within the ribosome, which is approximately 60% rRNA and 40% protein by weight. Ribosomes contain two major rRNAs and 50 or more proteins. The LSU and SSU rRNAs are found within the large and small ribosomal subunits, respectively. The LSU rRNA acts as a ribozyme, catalyzing peptide bond formation. rRNA sequences are widely used for working out evolutionary relationships among organisms, since they are of ancient origin and are found in all known forms of life.

Rubescent: Becoming red.

Rudimentary: Underdeveloped; immature.

Rufous: Brownish red.

Rugose: Wrinkled. Irregularly wrinkled.

Rugula: A small wrinkle.

Rugulose: Finely wrinkled.

Rugosissimus: Extremely rugose or wrinkled.

Russet: Reddish-brown.

S: Standard deviation.

s.n.: Side note: (a.s.n. = Another Side Note).

Saccate: Shaped like a sac (pouch-like).

Sacred Mushrooms (Synonymous With Teonanácatl): Any of various hallucinogenic mushrooms, usually pertaining to species in the genus *Psilocybe*, that have been ingested and produced a sacred (holy) experience. Note that many authors prefer the term "hallucinogenic" to "sacred." Others still, above hallucinogenic and sacred, prefer to more accurately label them as "active" or "neurotropic" fungi. Many other terms are used including "visionary" and "entheogenic."

Sapling (Pl. Saplings): 1. A young tree, but bigger than a seedling.

Saprophyte (Saprophytic, Saprobe, Sabrobic): An organism that grows on and derives its nourishment from dead or decaying organic matter.

Sarco-Hypha: Fleshy hyphae.

Sarcoskeletals: Longitudinally arranged, long-celled, inflated hyphae.

Sarcomitic: Any hyphal system in which thin-walled skeletals are present. This includes sarcodimitic and sarcotrimitic hyphal systems.

Sarcodimitic: 1. Consisting of generative hyphae and thick-walled, long, inflating fusiform elements. 2. Tissue consisting of generative hyphae and chains of very long, thin- to thick-walled elements ('sarcoskeletals').

sbf.: Sub-form. A taxonomic rank below form which is very rarely used.

Scale (Scales): Pileii bearing wart-like outgrowth, but unlike warts, scales are not distinct from the cap cuticle—rather, they are part of it. (See *Macrolepiota rachodes* for scales).

Scalp Section: A very thin, small section taken from either the center of the pileus surface or the upper stipe surface.

Sclerobasidium: Thick-walled basidium. Oftentimes, these are sterile basidium.

Sclerotium (Pl., Sclerotia): A (long-while) persisting compact mycelial body from which a basidiocarp can arise. Sclerotia are dense mycelium cells appearing in a stone-like or nut-like appearance.

Above: A sclerotium emerging from a mass of mycelium courtesy RMN (*P. galindoi*)

SDS: Sodium Dodecyl Sulfate.

Seceding: Lamellae at first attached to stipe, but later separating from it.

Secondary Angiocarpy: A type of angiocarpic development in which in its later stages the primordial hymenium is enveloped by hyphae originating from the stipe and/or the pileus.

Secondary Mycelium: A dikaryotic and binucleate mycelium characterized by clamp connections, crossing (anastomosis), and which is assimilative, not generative, in function. (Compare to "Primary Mycelium"). See also "Tertiary Mycelium".

Secondary Species: The species subordinate to the dominant species.

Secondary Species Criteria (Secondary Species Criterion): An alternative species concept adopting a different property of lineages as a secondary defining property of species (i.e. mating studies, full genomic comparison, or any additional alternative method to primary species criteria).

Secotiaceae: A family of fungi that have a stalk and cap and a wrinkled mass of tissue (the gleba) where spores are produced; are often dismissed as misshapen forms of other fungi.

Section (Abbreviated sect.): In botany, a section (Latin: Sectio) is a taxonomic rank below the genus, but above the species. The subgenus, if present, is higher than the section, and the rank of series, if present, is below the section. Sections are typically used to help organise very large genera, which may have hundreds of species.

Secotioid: Secotioid fungi are an intermediate growth form between mushroom-like hymenomycetes and closed bag-shaped gasteromycetes, where an evolutionary process of gasteromycetation has started but not run to completion. Secotioid fungi may or may not have opening caps, but in any case they lack the vertical geotropic orientation of the hymenophore needed to allow the spores to be dispersed by wind, and the basidiospores are not forcibly discharged.

Sector (Sectoring): When multi-spore cultivation attempts on agar show the same species having multiple strains. This creates division lines between these strains. A sector will have a distinct line of separation between it and adjacent ones. See *isolate*.

Sector selection: An individual mushroom can be composed of more than one strain of mycelium. When agar is used to study multi-spore growth, it is very common to see a multitude of strains (in the same petri plate) with visible barriers of division (open spaces of incompatibility). A sector will have a distinct line of separation between it and adjacent ones. When studying strains and attempting to select the best mushroom culture (fruiting abundance, aesthetic appearance, taste, etc) sector selection involves picking the right area(s) of the mycelium for studies in spawn creation and substrate growth.

Segmentiform: Lamellae with straight lamella edge and convex upper side.

Seismic Coda Scales (Polygraph-Like Scales, Snakeskin Fibers): Stem pattern macroscopically resembling some seismic coda and polygraph charts.

xyz

Above: One of several macroscopic stem hyphal patterns, this stem is more accurately referred to as having *polygraph-like scales*.

SEM (S.E.M.): A scanning electron microscope (SEM) is a type of electron microscope that images a sample by scanning it with a beam of electrons in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography, composition, and other properties such as electrical conductivity.

Semixerophytic (Semi-xerophytic): A habitat that is quite dry; a somewhat dry and arid habitat.

Senescence (Senescent): Having grown old. *Senescence* or *biological aging* is the change in the biology of an organism as it ages after its maturity. Such changes range from those affecting its cells and their function to those affecting the whole organism. There are a number of hypotheses as to why senescence occurs; for example, some posit it is programmed by gene expression changes, others that it is the cumulative damage caused by biological processes. Senescence is not the inevitable fate of all organisms. A variety of organisms, including some cold-blooded animals, have negligible senescence. Whether senescence as a biological process can be slowed down, halted or even reversed, is a subject of current scientific speculation and research. The word *senescence* is derived from the Latin word senescere, meaning "to grow old", from senex, meaning old man, old age, or advanced in age. ***Cellular senescence*** is the phenomenon by which normal diploid cells lose the ability to divide, normally after about 50 cell divisions in vitro. Some cells become senescent after fewer replication cycles as a result of DNA double strand breaks, toxins, etc. This phenomenon is also known as "replicative senescence", the "Hayflick phenomenon", or the Hayflick limit in honour of Dr. Leonard Hayflick, co-author with Paul Moorhead, of the first paper describing it in 1961. In response to DNA damage (including shortened telomeres), cells either age or self-destruct (apoptosis, programmed cell death) if the damage cannot be easily repaired. In this 'cellular suicide', the death of one cell, or more, may benefit the organism as a whole. For example, in plants the death of the water-conducting xylem cells (tracheids and vessel elements) allows the cells to function more efficiently and so deliver water to the upper parts of a plant. The ones that do not self-destruct remain until destroyed by outside forces.

Sensu: Sensu is a Latin word meaning "in the sense of". It is used in a number of fields including biology, geology, linguistics, and law. Commonly it refers to how strictly or loosely an expression is used in describing any particular concept, but it also appears in expressions that indicate the convention or context of the usage. A related convenient usage is in conjunction with a concept author citation ("sec. Smith", or "sensu Smith"), indicating that the intended meaning is the one defined by that author. (Here the meaning of "sec." is "secundum": "in accordance with".) Such an author citation is different from the (more common) citation of the nomenclatural author citation. The author citation refers only to the type of the name, the specimen or specimens that one refers to in deciding whether other specimens are members of that species or not. Given that an author (such as Linnaeus, for example) was the first to supply a definite type specimen and to describe it, it is to be hoped that his description would stand the tests of time and criticism, but even if it does not, then as far as practical the name that he had assigned will apply. It still will apply in preference to any subsequent names or descriptions that anyone proposes, whether his description was correct or not, and whether he had correctly identified its biological affinities or not. This does not always happen of course; all sorts of errors occur in practice. For example, a collector might scoop a netful of small fish and describe them as a new species; it then might turn out that he had failed to notice that there were several (possibly unrelated) species in the net. It then is not clear what he had named, so his name can hardly be taken seriously, either s.s. or s.l.

Sensu Amplo: In a relaxed/more relaxed/most relaxed sense.

Sensu Lato: This terms means "In the broad sense" (especially of a taxon, that is including all its subordinate taxa and/or other taxa other times considered as distinct). A term in taxonomy to specify which circumscription of a given taxon is meant, where more than one circumscription has been defined. Abbreviated in publication with *s.l.*

Sensu Auct. (Sensu Auctt.): In the general sense of the author. As generally used by the species' author, but specifically excluding the full, original meaning/context/application that the author had given. As used by the cited author, but specifically excluding the original meaning.

Sensu Stricto: In the strict sense. Abbreviated in publication with *s.s.* or *s.str.*

Separable Gelatinous Pellicle: A clear, thin gel-like layer on the surface of the cap of some mushrooms which can be removed.

Septa: A wall that separates one hyphae from the next and can allow for the exchange of organelles.

Septate: Having septum (septa).

Septation: The division or partitioning of a cavity into parts by a septum.

Septocystidia: Thin to thick-walled, cylindrical, smooth or slightly encrusted tramal cystidia with several septa, often with clamps. In case of thick-walled cystidia the apex is thin-walled.

Septum: A partition dividing filamentous hyphae into discrete cells in fungi.

Sequence Alignment: A sequence alignment is a way of arranging the sequences of DNA, RNA, or protein to identify regions of similarity that may be a consequence of functional, structural, or evolutionary relationships between the sequences.

Sericeous: Pileus and/or stipe surfaces are covered with fine, straight, adpressed, glossy hairs or fibrils.

Serrated: Toothed and like a saw (usually in reference to a pileus margin or gill margin being serrated). Having or denoting a jagged edge. Sawlike.

Serrulate: Edge minutely serrate.

Sessile: Cystidia without a stalk.

Seta: Long, pointed lamprocystidia which turn brown to brownish-black in KOH. Not found in gilled mushrooms.

Setae: Setae refer to dark brown, thick-walled, thorn-like cystidia found in corticioid and poroid fungi in the family Hymenochaetaceae. Though mainly microscopic, the setae of some species may be sufficiently prominent to be visible with a hand lens.

Setiform (Synonymous with Setidiform): 1. Narrowly conical with thickened wall. Having the form of a seta. Bristle-shaped. 2. Lamprocystidia which are long and pointed and do not react with KOH.

Setoid: In mathematics, a setoid (also called an E-set) is a set (or type) equipped with an equivalence relation.

Setule: Skillet-shaped, pointed lamprocystidia frequently associated with small, setiform lamproystidia.

Spherocystoderm: Cortical layer or pilieipellis layer consisting of a single outer layer of spherical cells.

Short Arm: Part of a chromosome (compare to Long Arm). They are separated from each other only by a primary constriction, the centromere, the point at which the chromosome is attached to the spindle during cell division.

Sicyoid (Synonymous with Lageniform and Cucurbitiform): Swollen at the base with the middle and top part tapered into a long beak, like a gourd, therefore gourd-like.

Siderophilous: 1. Of basidia, with granules that darken when heated in acetocarmine. 2. Tending to absorb iron.

Side View of Spore (Synonymous with Profile View and Dorsiventral View): zzz. Note: Many asymmetrical spores can appear symmetrical in face view while being asymmetrical in side view).

Siderophilous: Particles in basidia turning blackish purple or blackish violet in acetocarmine in presence of metal ions.

Silate (Synonymous with Psilate): Almost smooth.

Silent Mutation: DNA mutations that do not result in a change to the amino acid sequence of a protein, or that do result in amino acid change but do not result in radically different properties of the changed amino acids.

Simple Cutis: The hyphae making up the cuticle (the outer tissue of either the stipe or pileus) lie more or less flat on the surface of the mushroom.

Singer: Singer is used to indicate Dr. Rolf Singer as the author when citing a species name.

Dr. Rolf Singer
in Nevado de Toluca (Mexico)
(photo by Guzmán, 1958)

Above: Dr. Rolf Singer Courtesy Wikimedia Commons

Single Annulus: Annulus which is composed of one layer of tissue.

Sinuate: Lamellae having a concave indentation near the stipe.

Sinuous Stipe: A stipe having many curves and turns.

Skeletal Hyphae: Thick-walled, little, branched, non-septate hypha.

Skin (Synonymous with Cuticle and Pileipellis): The outer layer of the pileus.

Slightly Depressed: Pileus with shallow depression.

Small Nuclear Ribonucleic Acid (snRNA): Commonly referred to as U-RNA, snRNA is a class of small RNA molecules that are found within the nucleus of eukaryotic cells. The length of the an average snRNA is approximately 150 nucleotides. They are transcribed by either RNA polymerase II or RNA polymerase III, and studies have shown that their primary function is in the processing of pre-mRNA (hnRNA) in the nucleus. They have also been shown to aide in the regulation of transcription factors (7SK RNA) or RNA polymerase II (B2 RNA), and maintaining the telomeres. snRNA are always associated with a set of specific proteins, and the complexes are referred to as small nuclear ribonucleoproteins (snRNP) often pronounced "snurps". Each snRNP particle is composed of several Sm proteins, the snRNA component, and snRNP specific proteins. The most common snRNA components of these complexes are known, respectively, as: U1 snRNA, U2 snRNA, U4 snRNA, U5 snRNA, and U6 snRNA.

Smith (A.H. Smith): Described by Dr. Alexander H. Smith. 1904-1986.

Above: Dr. A.H. Smith, mycologist

Smooth: 1. Term to describe a spore's ornamentation when there is no visible ornamentation. It's smooth all around. 2. In reference to the pileus and stipe surfaces, being without eleveations, ridges, grooves, or veins (etc).

Snips: A single-nucleotide polymorphism (SNP, pronounced snip; plural snips). A SNP is a DNA sequence variation occurring when a single nucleotide — A, T, C or G — in the genome (or other shared sequence) differs between members of a biological species.

snRNP: snRNPs (pronounced "snurps"), or small nuclear ribonucleoproteins, are RNA-protein complexes that combine with unmodified pre-mRNA and various other proteins to form a spliceosome, a large RNA-protein molecular complex upon which splicing of pre-mRNA occurs. The action of snRNPs is essential to the removal of introns from pre-mRNA, a critical aspect of post-transcriptional modification of RNA, occurring only in the nucleus of eukaryotic cells.

Solid: Stipe made up of homogenous tissue.

Solitary: Growing alone.

Soluble In Ammonia: Dissolved and liquified in ammonia.

Sp.: Abbreviation for species.

Sp. Nov.: New species. Abbreviation for new species.

sp. nov., nom. rev.: Species new, name revised.

Spacer Cells: For instance, cystidia and pseudoparaphyses.

Spathulate: Hounded oblong, narrower at the base than the apex.

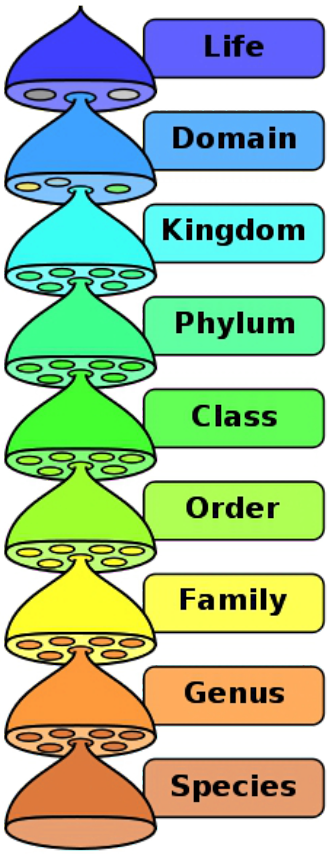
Spathuliform: Pileus elliptic or oblong tapering gradually towards stipe.

spec. nova.: New species.

Specialized Hyphae: Hyphae cells that are unique in form and/or function. There are several different types of specialized hyphae.

Speciation: Speciation is the evolutionary process by which new biological species arise.

Species: A fundamental category of taxonomic classification, ranking below a genus or subgenus and consisting of related organisms capable of interbreeding.



Above: Earth's taxonomy (classification) system. Courtesy Wikimedia Commons.

Species Concept: In biology, a species is one of the basic units of biological classification and a taxonomic rank. A species is often defined as a group of organisms capable of interbreeding and producing fertile offspring. While in many cases this definition is adequate, the difficulty of defining species is known as the species problem. The "species concept" is a human term and a human attempt to categorize life forms, including fungi, into finely tuned groups. However, Nature does not always display species in a consistent and definitive manner. Variations occur, environmental changes or adaptations occur, and other caveats can be seen when closely studying species of fungi.

Species Conceptualization: the conceptual problem of defining the species category by using one or more "species concepts" such as the biological species concept, the DNA (genetic) species concept, etc.

Species Delimitation: Rather than an attempt to clarify a species by using a species concept (ie the biological species concept, etc), species delimitation is a scientific concern to address the methods used by scientists to determine the appropriate methodological evidence used to infer the boundaries of a species. Species delimitation is also concerned with determining the numbers of species.

Species Problem (The Species Problem): The species problem is a mixture of difficult, related questions that often come up when biologists define the word "species". Definitions are usually based on how individual organisms reproduce, but biological reality means that a definition that works well for some organisms (e.g., birds) will be useless for others (e.g., bacteria). One common, but sometimes difficult, question is how best to decide which species an organism belongs to, because reproductively isolated groups may not be readily recognizable; cryptic species may be present. Another common problem is how to define reproductive isolation, because some separately evolving groups may continue to interbreed to some extent, and it can be a difficult matter to discover whether this hybridization affects the long-term genetic make-up of the groups. Many of the debates on species touch on philosophical issues, such as nominalism and realism, as well as on issues of language and cognition. The current meaning of the phrase "species problem" is quite different from what Charles Darwin and others meant by it during the 19th and early 20th centuries. For Darwin, the species problem was the question of how new species arose: Speciation.

Sphaerocyst: Round or swollen cell in flesh of certain mushrooms, particularly Russula and Lactarius.

Sphaerocyte: Round cell of pellis or veil.

Sphaerocysts: Round swollen cells usually formed in clusters, characteristically found in the Russulaceae.

Sphaeropedunculate: Cystidia in which the apical portion is swollen into a spherical tip and tapers abruptly near the middle to an elongated basal peg or peduncle.

Spherical (Synonymous with Globose): Having the shape of a sphere or ball.

Spherocystoderm: With reference to a cortical layer, the cells are spherical and in a single layer.

Spheropedunculate: Cystidia globose or subglobose with long stalk.

Spinose (Synonymous with Echinate): Bearing many spines.

Spinulose: Finely spiny.

Spiral Hyphae: Hyphae that end in a flat or helical coil, or hyphae that maintain from top to bottom a spiral appearance.

Spiral Incrustations: Winding or circling patterned crust.

Spitzenkörper: The Spitzenkörper is a structure found in fungal hyphae which is the organizing center for hyphal growth and morphogenesis. It consists of many small vesicles and is present in growing hyphal tips,

during spore germination and where branch formation occurs. Its position in the hyphal tip correlates with the direction of hyphal growth. The spitzenkörper is a part of the endomembrane system system in fungi. Hyphae grow at their tips. During tip growth, cell walls are extended by the external assembly and polymerization of cell wall components, and the internal production of new cell membrane. The spitzenkörper is an intracellular organelle associated with tip growth. It is composed of an aggregation of membrane-bound vesicles containing cell wall components. The spitzenkörper is part of the endomembrane system of fungi, holding and releasing vesicles it receives from the Golgi apparatus. These vesicles travel to the cell membrane via the cytoskeleton and release their contents outside the cell by the process of exocytosis, where it can then be transported to where it is needed. Vesicle membranes contribute to growth of the cell membrane while their contents form new cell wall. The spitzenkörper moves along the apex of the hyphal strand and generates apical growth and branching; the apical growth rate of the hyphal strand parallels and is regulated by the movement of the spitzenkörper.

Spliceosome: A spliceosome is a complex of snRNA and protein subunits that removes introns from a transcribed pre-mRNA (hnRNA) segment. This process is generally referred to as splicing.

Spore (Pl., Spores) (from gilled mushrooms): 1. Spores are the reproductive structure of gilled mushrooms - like seeds from a plant in many ways. Meiosis is used in order to develop. Spores are specialised cells of the fungus that can function as resting or dispersal propagules. Each spore has the potential to generate another individual of the species. Spores that come from basidia (versus asci for instance) are called *basidiospores*. 2. A reproductive cell capable of developing into a new individual without fusion with another reproductive cell. Spores thus differ from gametes, which are reproductive cells that must fuse in pairs in order to give rise to a new individual. Spores are agents of asexual reproduction, whereas gametes are agents of sexual reproduction.

Spore Attachment: It's important to describe how a spores are attached to a basidium.

Spore Cavity: An opening in the cell wall of a spore, namely the germ pore.

Spore Germination: The process of a spore developing hypha/hyphae.

Spore Measurement Abbreviations: Q is the spore quotient (length divided by width), Qe is the median Q-value, Me is the median, C is the number of entities within the brackets, N is the number of measured entities. See the entry for "Spore Statistics".

Spore Quotient (Abbreviated "Q"): Calculate the spore quotient dividing the spore length by the spore width.

Spore Range: For instance spores measures 9-11 microns x 5-7 microns.

Spore Statistics: Scientific statistics of spore measurements include length and width of 30 to 55 spores followed by their maximum length, maximum width, minimum length, minimum width, average, spore length range, spore width range, median, and quotient. Some mycologists also take L-W (Length minus Width) which is synonymous with L-D (Length minus Diameter).

Spore Wall: Sometimes the spore wall has several layers. Of these the endosporium is the innermost, and

is usually quite thin. Sometimes the developing spore is enveloped by a membrane called a perisporium, which usually sloughs off as the spore matures; R. Heim, in his R. Heim (1931) Le genre Inocybe that this should be called the peripheral envelope instead, at when talking about Inocybes. The episporium is considered the fundamental layer of the spore wall; it is the thickest, gives rise to whatever ornamentation there is, and is also responsible for the spore's color. The mesosporium sometimes occurs, in between the episporium and the endosporium; and the exosporium sometimes covers the episporium (and is pierced by its ornamentation) but is in turn covered by the perisporium.

Sporidium (Pl., Sporidia): A secondary spore, or a filament produced from a spore, in certain kinds of minute fungi. A spore.

Sporocarp: In fungi, the sporocarp (also known as fruiting body or fruit body) is a multicellular structure on which spore-producing structures, such as basidia or asci, are borne. The fruiting body is part of the sexual phase of a fungal life cycle, with the rest of the life cycle being characterized by vegetative mycelial growth and asexual spore production. The sporocarp of a basidiomycete is known as a basidiocarp, while the fruiting body of an ascomycete is known as an ascocarp. A significant range of different shapes and morphologies are found in both basidiocarps and ascocarps; these features play an important role in the identification and taxonomy of fungi.

Sporoid: A very limited number of students have chosen to measure spores without including the ornamentation. This type of measurement is known as a sporoid (or sporoidal) measurement.

Sporophore: An organ in fungi (such as a basidium) that produces or carries spores.

Sporopore (Synonymous with Germ Pore): A soft spot in the wall of certain spores, through which the fungus first starts to grow, same as apical pore (but not the same as apiculus).

spp.: Abbreviation used for a group of species. This abbreviation can be contrasted with the abbreviation sp. which is designated as an abbreviation for a single species rather than a group of species.

Sputter Coater (Sputter Coating): Sputter coating in scanning electron microscopy is the process of covering a specimen with a thin layer of conducting material, typically a metal, such as a gold/palladium (Au/Pd) alloy. A conductive coating is needed to prevent charging of a specimen with an electron beam in conventional SEM mode (high vacuum, high voltage). A metal coating is useful for increasing signal to noise ratio (heavy metals are good secondary electron emitters).

Squamose: Pileus or stipe surface is covered with coarse (adpressed) scales.

Squamule (Pl., Squamules): A small scale. Small scales, usually referring to the pileus surface.

Squamulose: Pileus or stipe surface covered with minute scales.

Squarrose: Pileus or stipe surface covered with projecting coarse scales.

Squarrulose: Pileus or stipe surface is covered with small projecting scales.

ssRNA: Single stranded RNA (Single-stranded ribonucleic acid).

SSU Region: Small SubUnit Region. A coding region of DNA.

st., stat.: Status.

Statismospore: Spores which are not forcibly discharged from the basidium. These spores are usually axially symmetrical.

Statismosporic Basidium: A basidium that does not discharge its spores; they simply break off from the sterigmata.

Stat. Nov.: Status novus (name at new rank).

Stellate: Star-shaped.

STEM (Scanning Transmission Electron Microscopy): A scanning transmission electron microscope (STEM) is a type of transmission electron microscope (TEM). As with any transmission illumination scheme, the electrons pass through a sufficiently thin specimen. However, STEM is distinguished from conventional transmission electron microscopes (CTEM) by focusing the electron beam into a narrow spot which is scanned over the sample in a raster. The rastering of the beam across the sample makes these microscopes suitable for analysis techniques such as mapping by energy dispersive X-ray (EDX) spectroscopy, electron energy loss spectroscopy (EELS) and annular dark-field imaging (ADF). These signals can be obtained simultaneously, allowing direct correlation of image and quantitative data. By using a STEM and a high-angle detector, it is possible to form atomic resolution images where the contrast is directly related to the atomic number (z-contrast image). The directly interpretable z-contrast image makes STEM imaging with a high-angle detector appealing. This is in contrast to the conventional high resolution electron microscopy technique, which uses phase-contrast, and therefore produces results which need interpretation by simulation. Usually STEM is a conventional transmission electron microscope equipped with additional scanning coils, detectors and needed circuitry; however dedicated STEMs are manufactured also.

Stenospore: Projectile-shaped or bullet-shaped.

Sterigma (pl., sterigmata): The extension-tips located at the tops of basidia which hold spores until they are ejected.

Sterigmal appendage: A nipple-like protuberance on the spore where it was connected to a sterigma. With many species, the opposing end of the spore is dimpled with a germ pore.

Sterile: 1. Lamella edge composed of cystidia only. 2. Unfertile (non-reproductive cells).

Sterile Syring Method: Using a new or used syringe, wipe down the exterior, including the metal syringe tip, with rubbing alcohol & paper towel. In a pot, bring distilled water to a rolling boil. Draw up as much water as possible into the syringe and wait 90 seconds to eject the water into a separate container for disposal. Continue by drawing two more times using the same time frame before ejecting the water.

Depending on the task, the syringe tip can now be flame sterilized (until glowing hot), recapped and stored in a new ziplock bag - or filled with sterile water (again from the pot) for a spore solution once cooled.

Stichobasidium: Basidium in which the spindles of the second meiotic division are vertical, and which are parallel to the longitudinal axis of the basidium.

Stipe: A synonym for stem. Rarely, the term "stalk" is also used to describe the stipe (ie the stem).

Stipe Scalp Section: A very thin, small section taken from the stipe surface, usually from the upper area of the stipe.

Stipe Trama: Although the stipe trama is continuous with the pileus trama, an imaginary line conveniently separates the stipe from the pileus. Below this line the hyphae of the stipe trama run more or less longitudinally yet they frequently intertwine. Many mushrooms have stipe strama composed of typical thread-like hyphae interlaced with laticefers, oleiferous hyphae, or sphaerocysts. The hyphae of the pileus and stipe trama can vary in the following ways: the thickness of the wall, the type of branching, the presence or absence of clamp connections and their presumed functions. They can also possess a variety of pigments, and can react with different chemical reagents.

Stipitate: Possessing or supported by a stem (stipe).

Stipitipellis (Synonymous with Stipitopellis): The outer tissue of the stipe.

Stipitocarpy: A type of development of the basidiocarp in which the first differentiating hyphae of the primordium are those of the stipe.

Stirps (Stirpes): A line of descendants from a common ancestor. (Botany) A race or variety, especially one in which the characters are maintained by cultivation.

Straight: Margin of pileus not bent upwards or inwards.

Stramineous: Chaffy; like straw; straw-colored.

Stria (Pl., Striae): Lines or fine grooves which may be parallel or radiating

Striate: Having parallel or radiating fine lines, or fine ridges.

Striate Margin: Margin of pileus having parallel or radiating fine lines, or fine ridges.

Striations: Another special kind of wrinkle on the cap. The top surface of the pileus will collapse against the gills (usually at the margin), producing a zone of short, parallel ridges (lines) that are called striations.

Striatulate: Marked by small lines, grooves or ridges.

Strobiculate: Having many shallow depressions, grooves, or pits.

Strongly nodulose spores: Spores with small knoblike outgrowths. See spores from *Inocybe napipes*.

Strophariaceae: The Strophariaceae are a family of fungi in the order Agaricales. The family currently contains 18 genera and 1316 species. The species of Strophariaceae have a red-brown to dark brown spore print, while the spores themselves are smooth and have an apical germ pore. These agarics are also characterized by having a cutis-type pileipellis. Ecologically, all species in this group are saprotrophs, growing on various kinds of decaying organic matter.

Stub (SEM Pin Stub): Used to hold specimen for scanning electron microscopes.

Stuffed: Stem is stuffed with loose material in the interior - versus being either hollow or solid throughout.

Above: Stipe showing neither hollow nor solid hyphae, but *stuffed* hyphal tissue

Subadnexed: 1. Gills almost narrowly attached to the stipe. 2. Lamellae slightly (almost) rounded towards stipe.

Subalate: Ribbed.

Subannulus: A sometimes fibrillose (covered with hair-like projections) zone where the annulus or annular zone is expected to occur on the stipe. Resembling an annulus but not a true annulus resulting from the

partial veil.

Subarachnoid Membrane:

Subbulbous: Less than fat, round, or bulging.

Subcapitate: Almost capitate, barely inflated and not distinctly covered by a cap.

Subclose: A term used occasionally of gill spacing, intermediate between close and crowded, might also be used to mean more or less close.

Subconvex: Almost domed.

Subcoprophilous: Associated with dunged fields rather than dung itself.

Subcrowded: A term used occasionally of gill spacing, intermediate between close and crowded, might also be used to mean more or less crowded.

Subcylindric: Nearly cylindrical.

Subdecurrent: Lamellae slightly decurrent (extending downward).

Subdistant: Refers to gill spacing, intermediate between close and distant, the order being crowded, (subcrowded), (subclose), close, subdistant, distant.

Subellipsoid: Somewhat ellipsoid.

Subfusiform (Synonymous with Boletiform): Mushroom-shaped.

Subgeneric: A grouping less inclusive than a genus but more than a species.

Subgenus (Pl., Subgenera): A grouping less inclusive than a genus but more than a species. Usually the term "clade" or "section" is used to describe a grouping of species within a genus.

Subgelatinous: Imperfectly or partially gelatinous.

Subgills: The short gills that do not span the entire distance from margin to stem.

Subglobose: 1. Not quite globose. Almost globose. 2. Spore Q=1.05-1.15. 3. Cystidia Q=1.05-1.15.

Subgregarious: Growing in a small group or growing in a group of widespread specimens.

Subheteromorphus: A type of gill edge in which the cheilocystidia are similar to the pleurocystidia.

Subhexagonal: Refers to shape of spores. Less than hexagonal (a polygon having six angles and six sides).

Subhymenium (Sub-Hymenium) (Pl., Subymenia): A differentiated tissue just beneath the hymenium. Consists of small, short hyphae.

Subicule (Subiculum): A net-, wool-, or crust-like growth of mycelium under fruiting bodies.

Subisodiametric: Of spore sizes, the average length divided by the average width has a value from 1.16-1.27: with isodiametric spores this value is 1.0-1.15, and with heterodiametric spores it is greater than 1.27.

Sublageniform: Slightly lageniform. Almost lageniform. Almost shaped like a flask.

Sublentiform: Shaped somewhat like a biconvex lens.

Sublimoniform: Almost lemon-shaped.

Sub-Membranous (Submembranous): Almost resembling a membrane. (A membrane is the thin, limiting covering of a cell or cell part).

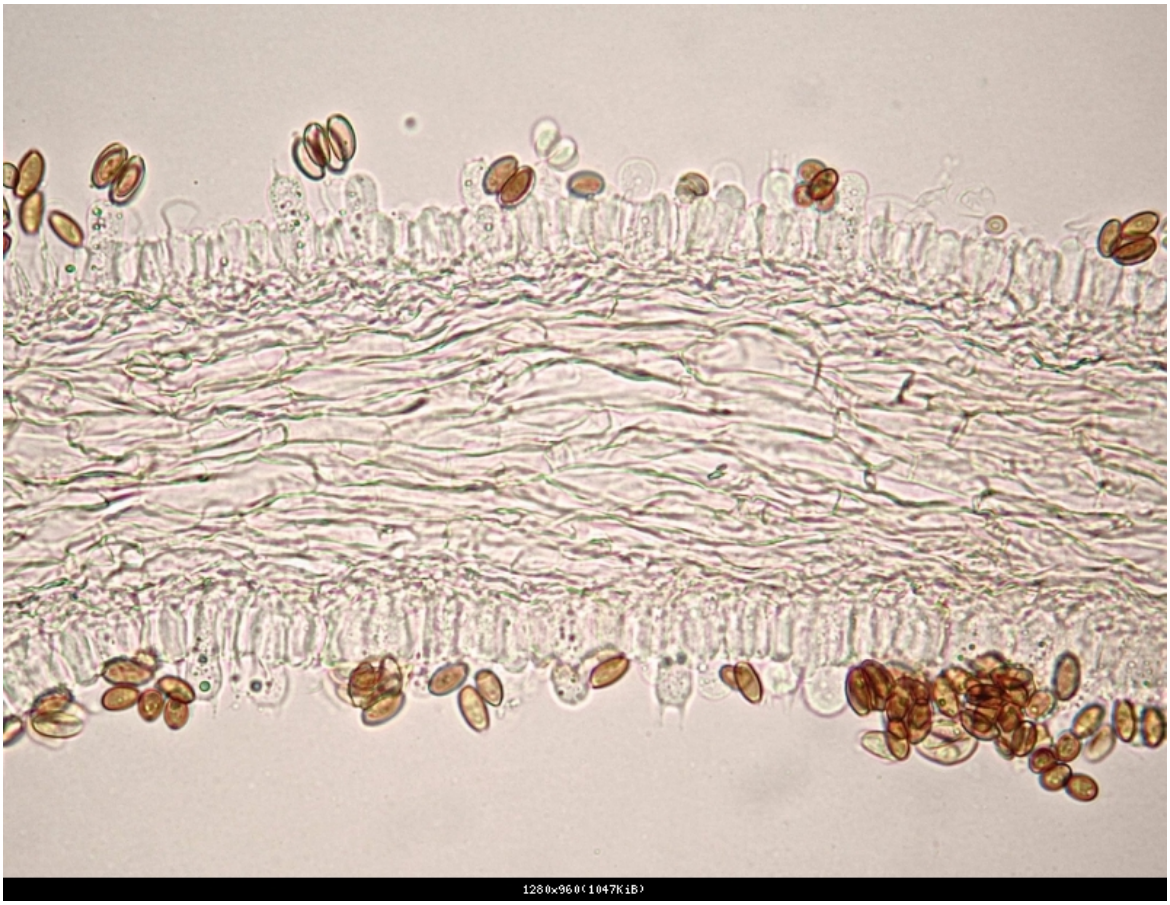
Subovate: Not quite ovate. Almost ovate.

Subparallel: Not quite parallel. Almost parallel.

Subpellis: The lowermost layer of the pileipellis. or the lowermost layer of the stipitipellis or bulbipellis.

Subregular Lamellar Trama (Subregular Lamellar Hyphae): Hymephoral trama having slightly flexuouse, nearly parallel hyphae.

Below: An arguably subregular trama at 100x magnification of *Psilocybe pelliculosa* courtesy of Mycologist Alonso Cortés-Pérez



Subrhomboid: Somewhat rhomboid (leaf shaped like a parallelogram with adjacent sides of unequal length).

Subspecies: Subspecies (commonly abbreviated "subsp." or "ssp.") in biological classification is either a taxonomic rank subordinate to species. In botany, subspecies is one of many ranks below that of species, such as variety, subvariety, form, and subform. In mycology, particularly with gilled mushrooms, it is more common to use the term "variety" instead of using "subspecies."

Subspherical: Not quite spherical. Almost spherical.

Substerile: Basidiospores are very scarce.

Substrate (Synonymous with Substratum and Substrata): The material, such as soil and wood chips, that a fungi is growing on.

Subtomentose: With a somewhat dense layer of matted down or soft hairs; or like a newly sheared lamb.

Subulate: Tapering to a point; awl-shaped.

Subumbilicate: Area on pileus possessing an almost naval-like depression but not blatantly umbilicate.

Subumbonate: Pileus having low broad umbo. Having a slight umbo.

Subunit Ribosomal RNA: Ribosomal RNAs form two subunits, the large subunit (LSU) and small subunit

(SSU).

Subventricose: Not quite ventricose. Almost ventricose.

Subventricose-Rostrate: Swollen, especially on one side or unequally; protuberant - and beak like.

Subvesiculose: Cell(s) almost swollen or appearing inflated like a large sac or bladder (vesicle), with only the base abruptly tapered.

Subviscid: Slightly sticky, thinly viscid.

Sulcate: With grooves. Furrowed.

Sulphidium (pl., sulphidia): Pleurocystidium that have a yellowish coloration (similar to that of of a chrysocystidium). So far this term has been used extremely infrequently. E. Gerhardt, in his monograph on Panaeolus (*Taxonomische revision der gattungen Panaeolus und Panaeolina, Bibliotheca Botanica 47, 1996*), defines sulphidia as follows (translation from German): "There are pleurocystidia, so far called chrysocystidia but not matching this definition as they do not stain yellow with KOH (unlike Stropharia and Hypholoma), but they are yellowish from the very beginning or keep uncolored. They become a beautiful red wine in sulphovanillin (sulfo-vanillin, sulpho-vanillin), consequently they are called sulphidia." The stain *patent blue* may be useful as an alternative to sulphovanillin.

Superior: Of a ring, forming on the upper part of the stem.

Suprahilar Disc (Synonymous with Suprahilar Plage): Refers to spores that show a rounded, smooth area just above the hilar appendage.

Suprahilar Depression: Refers to spores that have a sinking area just above the hilar appendage.

Suprahilar Plage: Refers to spores that show a rounded, smooth area just above the hilar appendage.

Suprapellis: The outermost layer of the pileipellis, or the outermost layer of the stipitipellis or bulbipellis.

Surface Tension Catapult: Reference to how spores eject in connection with a Buller's Drop. The swift coalescence of the Buller's Drop with additional water causes a sudden shift in the center of mass of the spore and contributes to its release from the sterigma.

Symmetrical (Symmetrical Spores): Have a balanced symmetry when comparing two opposing side views. Spores are called either symmetrical or asymmetrical as an identifying trait.

Symmetry: 1. Correspondence in size, form, and arrangement of parts on opposite sides of a plane, line, or point; regularity of form or arrangement in terms of like, reciprocal, or corresponding parts. 2. Proper or due proportion of the parts of a body or whole to one another with regard to size and form; excellence of proportion.

Syn.: Synonym, synonymous with.

Synanamorph (Synanamorphs): When a single fungus produces multiple morphologically distinct anamorphs, these are called synanamorphs.

Synapomorphic: A derived trait shared by two or more taxa that is believed to reflect their shared ancestry.

Synapomorphy: In cladistics, a synapomorphy or synapomorphic character is a trait that is shared ("symmorphy") by two or more taxa and their most recent common ancestor, whose own ancestor in turn does not possess the trait. A synapomorphy is thus an apomorphy visible in multiple taxa, where the trait in question originates in their last common ancestor.

Syngamy: 1. The union of two gametes to form a zygote in fertilization. 2. A method of reproduction in which two individuals (gametes) unite permanently and their nuclei fuse; sexual reproduction.

Synonym: Another name for the same species, especially an earlier or illegitimate name not currently used for the species; if two or more names are based on the same type, they are homotypic synonyms, sometimes indicated by three horizontal lines between the two names, but if they are based on different types, they are heterotypic, sometimes indicated by two horizontal lines between the two names; in this program, alternate names following the primary name are earlier or later or illegitimate names representing all or part of the concept of the primary name: the primary name includes the alternate name, but the alternate name may not include the whole taxon represented by the primary name.

Synoptic Keys: A taxonomic dichotomous key to identify species. Synoptic keys follow the taxonomic classification as close as possible. Keys which aim to reflect the scientific classification of organisms. (Compare to Diagnostic Keys).

Systematic Mycology: Mycological systematics is the study of the diversification of fungi, both past and present, and the relationships among living things through time. Relationships are visualized as evolutionary trees (synonyms: cladograms, phylogenetic trees, phylogenies). Phylogenies have two components, branching order (showing group relationships) and branch length (showing amount of evolution). Phylogenetic trees of species and higher taxa are used to study the evolution of traits (e.g., anatomical or molecular characteristics) and the distribution of organisms (biogeography). Systematics will allow us to understand the evolutionary history of life on Earth and in the case of mushrooms it will enable us to understand the order and relationship each species has within the kingdom fungi and beyond.

Systematics: Biological systematics is the study of the diversification of living forms, both past and present, and the relationships among living things through time. Relationships are visualized as evolutionary trees (synonyms: cladograms, phylogenetic trees, phylogenies). Phylogenies have two components, branching order (showing group relationships) and branch length (showing amount of evolution). Phylogenetic trees of species and higher taxa are used to study the evolution of traits (e.g., anatomical or molecular characteristics) and the distribution of organisms (biogeography). Systematics, in other words, is used to understand the evolutionary history of life on Earth. "Systematic biology" and "taxonomy" (terms that are often confused and used interchangeably) were defined in relationship to one

another as follows: Systematic biology (hereafter called simply systematics) is the field that (a) provides scientific names for organisms, (b) describes them, (c) preserves collections of them, (d) provides classifications for the organisms, keys for their identification, and data on their distributions, (e) investigates their evolutionary histories, and (f) considers their environmental adaptations. This is a field with a long history that in recent years has experienced a notable renaissance, principally with respect to theoretical content. Part of the theoretical material has to do with evolutionary areas (topics e and f above), the rest relates especially to the problem of classification. Taxonomy is that part of Systematics concerned with topics (a) to (d) above.

Systems Biology: Systems biology is an emerging approach applied to biomedical and biological scientific research. Systems biology is a biology-based inter-disciplinary field of study that focuses on complex interactions within biological systems, using a more holistic perspective (holism instead of the more traditional reductionism) approach to biological and biomedical research. Particularly from year 2000 onwards, the concept has been used widely in the biosciences in a variety of contexts. One of the outreaching aims of systems biology is to model and discover emergent properties, properties of cells, tissues and organisms functioning as a system whose theoretical description is only possible using techniques which fall under the remit of systems biology. These typically involve metabolic networks or cell signaling networks.

Tangential Slice (Tangential Section): This section starts at any point along the margin of the pileus and reaches the opposing side (of the cap) but does not travel through the true center (middle of the cap).

Taq Polymerase: A thermostable DNA polymerase frequently used in polymerase chain reaction (PCR), a method for greatly amplifying short segments of DNA.

Taxon: A taxon (plural: taxa) is a group of one (or more) populations of organism(s), which a taxonomist adjudges to be a unit. Usually a taxon is given a name and a rank, although neither is a requirement. Defining what belongs or does not belong to such a taxonomic group is done by a taxonomist with the science of taxonomy. It is not uncommon for one taxonomist to disagree with another on what exactly belongs to a taxon, or on what exact criteria should be used for inclusion.

Taxonomy: The study of the identification and nomenclature of organisms or things. Taxonomy, the science of classifying organisms, is based on phylogeny. Early taxonomic systems had no theoretical basis; organisms were grouped according to apparent similarity. Since the publication in 1859 of Charles Darwin's On the Origin of Species by Means of Natural Selection, however, taxonomy has been based on the accepted propositions of evolutionary descent and relationship.

Tawny: Brownish-orange.

Teleomorph: The sexual reproductive stage (morph), typically the fruiting body. (Contrast the term *teleomorph* with *anamorph*).

Teleomorph-Typified Name: The terms teleomorph, anamorph, and holomorph apply to portions of the life cycles of fungi in the phyla Ascomycota and Basidiomycota. Teleomorph describes the sexual reproductive stage (morph)of a basidiocarp.

Teonanácatl: "Flesh of the gods."

Terminal: The final part of a structure, usually referred to as a *Terminal Cell*.

Terminal Cells: The last or end cell on a multicellular organism. Differentiated and specialized cell with limited or no capacity to divide, also called terminally-differentiated cell.

Terminal Elements: The end hyphae in the pileipellis.

Terminal Hyphae Elements: The end hyphae in the pileipellis.

Terricolous: Living on or in the soil.

Tertiary Gills: A third form or third branching of gills from the primary gills.

Tertiary Mycelium: Mycelium arising from *secondary mycelium* that is involved in mushroom fruitbody formation. (Compare to Primary Mycelium and Secondary Mycelium).

Tetrapolar Sexuality: Four or more possible mating types.

Tetrasporic (Tetraspore): One of four spores produced from a tetrasporangium. Any of the asexual spores that are produced in groups of four in the sporangium

Tetrasporangium: A sporangium in which four spores (the tetraspores) are formed.

Thick-Walled Spores: **xyz** and zzz

Thick-Walled Hyphae: **xyz** and zzz

Tibiiform: Shape of a cystidia which is almost ventricose and has a long narrow neck with an apex that is swollen into a knob, like a tibia bone.

TM: Total magnification combining the eyepiece magnification with the objective magnification.

Tomentocutis: With reference to the cortical layer(s), the hyphae pattern is irregular, not inflated. Similar to a tomentum but compacted into a thin layer.

Tomentose: Pileus or stipe surface covered densely with matted, soft hairs.

Tomentulose: Covered with short fine hairs or fibrils, which may be matted like a thin woollen blanket or erect according to different authors' interpretations; nearly tomentose but less than subtomentose.

Tomentum: 1. A piliepellis or cortical layer consisting of irregularly arranged hyphae. 2. A mass of filamentous hairs.

Topography: The surface features of an object.

Topotype: A specimen of an organism taken from the type locality of that species.

Torulose (Synonymous with Moniliform): Having a cylindrical or ellipsoid body; swollen and constricted at intervals.

Tortuose: Wreathed; twisted; winding.

Trama (Tramal View): 1. An internal layer of hyphae cells revealed in a cross section of either the gills (gill trama), the cap (cap trama), or the stipe (stipe trama).

Tramal Cystidia (Synonymous with Endocystidia): Cystidia forming in the tramal tissue of the cap, or stipe.

Transfer RNA: A Transfer RNA (abbreviated tRNA and archaically referred to as sRNA abbreviating soluble RNA) is an adaptor molecule composed of RNA, typically 73 to 94 nucleotides in length, that serves as the physical link between the nucleotide sequence of nucleic acids (DNA and RNA) and the amino acid sequence of proteins.

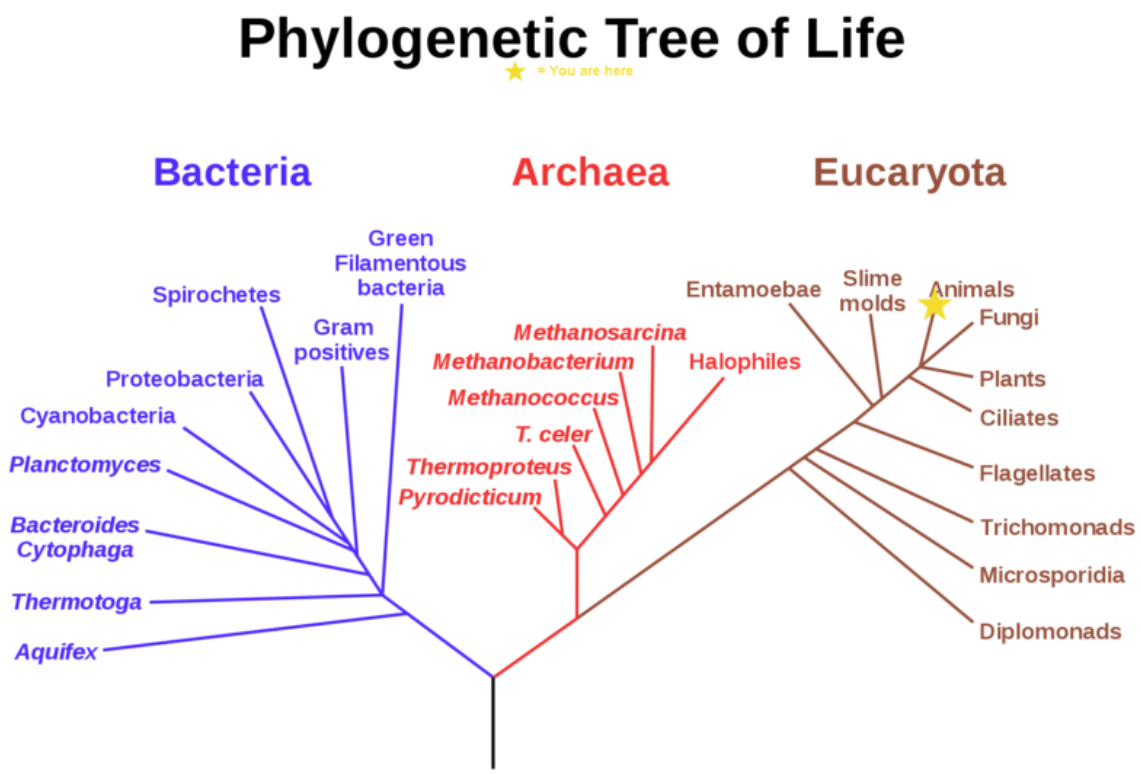
Translucently Striate: The cap margin is translucent, and the gills can be seen through it, creating a pattern that looks striate even though the surface of the cap is smooth.

Transvenose: Lamellae provided with veins on the surface.

Transverse Section: A cross section.

Trapeziform: Four sides two of which are usually parallel or no sides parallel.

Tree Of Life: Darwin envisioned a "tree of life" with branches representing currently living species and the base as the common ancestor of all. As one moved from the braches toward the trunk, one would pass the common ancestors for each species group.



Above: Courtesy Wikimedia Commons

Tree Length: Phylogenetic tree software value which scores the number of changes between different character states that at minimum are necessary to explain the observed data given the tree.

Triangular: Spores are rounded-triangular.

Tribe (Synonymous with Tribus): In biology, a tribe is a taxonomic rank between family and genus. It is sometimes subdivided into subtribes.

Trichiform (Synonymous with Aculeate): Having sharp prickles.

Trichocutis: With reference to the cortical layer(s), the hyphae are at first erect and later the hyphal ends are periclinal.

Trichoderm: (Note: Definition needs to be re-examined and compared between Vellinga, Watling, and Clémençon). 1. With reference to the cortical layer(s), the hyphae are erect, irregular to subregular, not or moderately inflated. 2. A pileipellis made up of erect straight elements, septate (and/or) not originating at the same level. Compare to intricate trichoderm and irregular trichoderm.

Trichohymeniderm: A hymeniderm made up of elements with Q > 6.

Tricholomatoid: Characterized by lamellae neither free, nor decurrent; stipe more or less as long as diameter of pileus; context fleshy; context of pileus continuous with context of stipe.

Trimitic: Trama hyphae possessing three types of hyphae (generative hyphae, skeletal hyphae, and binding hyphae). Note: The binding hyphae are thick-walled, distinctly branched, tortuous, often lacking

a lumen. Compare the term *trimitic* with *monomitic* and *dimitic*.

Truncate: Ending abruptly as if cut off.

Truncate Germ Pore: A germ pore that ends abruptly/cuts off.

Truncately Broadly Conical: Pileus broadly conical with as if cut off apex.

Truncately Conical: Pileus conical with as if cut off apex.

Tuberculate: Covered with tubercles (any small rounded nodule or elevation). With low bumps.

Tuberculate-Striate: Of cap margin, furrowed radially with small bumps on the ridges.

Tubulin: One of several members of a small family of globular proteins. The most common members of the tubulin family are α-tubulin and ß-tubulin. Sometimes used in DNA sequencing studies.

Turbinate: Cystidia which have a swollen apex and has a tapers near the middle, becoming quite abrupt at the base, like a top, and therefore top-shaped.

Twisted: Stipe fibrils arranged spirally round axis because of base of stipe being rotated with regard to apex.

Type Collection: A collection of a species of mushroom that was used to describe the species and have it added into nomenclature.

Type Locality: The place or source where a holotype or type specimen was found.

Type Specimen: A single specimen that was used to describe the species and add it into nomenclature. The scientific name of every taxon is almost always based on one particular specimen, or in some cases specimens. Types are of great significance to biologists, especially to taxonomists. Types are usually physical specimens that are kept in a museum or herbarium research collection, but failing that, an image of an individual of that taxon has sometimes been designated as a type. Describing species and appointing type specimens is part of scientific nomenclature and alpha taxonomy. When identifying material, a scientist attempts to apply a taxon name to a specimen or group of specimens based on his or her understanding of the relevant taxa, based on (at least) having read the type description(s), preferably based on an examination of all the type material of all of the relevant taxa. If there is more than one named type that all appear to be the same taxon, then the oldest name takes precedence, and is considered to be the correct name of the material in hand. If on the other hand the taxon appears never to have been named at all, then the scientist or another qualified expert picks a type specimen and publishes a new name and an official description.

Type Species: In biological nomenclature, a type species is the species to which the name of a genus is permanently linked; it is the species that contains the biological type specimen(s) of the taxon. A type species is both a concept and a practical system which is used in the classification and nomenclature (naming) of animals and plants. The value of a "type species" lies in the fact that it makes clear what is

meant by a particular genus name. This is an important concept whenever a taxon containing multiple species must be divided into more than one genus; the type species automatically assigns the name of the original taxon to one of the resulting new taxa, thus reducing the potential for confusion.

Type Section: 1. May refer to literally a section of material being studied from a type collection. 2. A phylogenetic tree section for species that are based on a type species.

Typonym: SImilar to synonym, *typonyms* are words that sound and mean the same but are spelled differently due to typographical error.

Ultra-High-Speed Video Microscopy:

Ultrastructure: The detailed structure of a biological specimen, such as a cell, tissue, or organ, that can be observed by electron microscopy. It refers in general to the study of cellular structures that are too small to be seen with an optical microscope. These cellular structures are known as organelles and allow the cell to function properly within its specified environment. The structures of an animal cell are the nucleus, endoplasmic reticulum (rough and smooth), Golgi apparatus, mitochondria, lysosomes, ribosomes, and centrioles. The plant cell has all of the above and the addition of a cell wall, and chloroplasts which aid photosynthesis.

Umbilicate: Pileus possessing a navel-like depression.

Umbo: Pileus possesses a broad, rounded knob.

Umbonate: Pileus possesses a broad, rounded knob.

Unbranched Gills: Gills which do not branch out (or fork out) into secondary, tertiary, or quaternary gills from a primary gill.

Uncinate: Gill attachment hooked; gill attachment in which they are attached with a short hook.

Undate: Waved.

Undulate (Undulating): Minutely undate. Wavy.

Uniform: Not changing in form or character, and remaining the same in all cases and at all times.

Uniguttulate: Spores with one droplet.

Uninucleate: With one nucleus.

Unique Binomial: A unique genus and species name. it cannot have the same species epithet as another species validly published in the same genus.

Universal Veil: The universal veil which initially covers the whole fruiting body including the top of the cap, always breaking and sometimes leaving fragments on the cap or the stem, or a volva at the base of

the stem. Protective tissue enclosing the whole of the developing fruit body. In mycology, a universal veil is a temporary membranous tissue that fully envelops immature fruiting bodies of certain gilled mushrooms. The developing Caesar's mushroom (Amanita caesarea), for example, which may resemble a small white sphere at this point, is protected by this structure. The veil will eventually rupture and disintegrate by the force of the expanding and maturing mushroom, but will usually leave evidence of its former shape with remnants. These remnants include the volva, or cup-like structure at the base of the stipe, and patches or "warts" on top of the cap. This macrofeature is useful in wild mushroom identification because it is an easily observed, taxonomically significant feature. It is a character present among species of basidiomycete fungi belonging to the genera Amanita and Volvariella. This has particular importance due to the disproportionately high number of potentially lethal species contained within the former genus.

Urticiform: Cystidia legeniform with a long, tapering neck and bearing needle-shaped crystals. Reminiscent of the nettle-cells of Urtica species.

Utriculate: Spores entirely enclosed by an outer spore wall in the form of loose sack.

Utriform: Of cystidia, with a slight constriction below a large round head, like a bladder, therefore bladder-shaped.

Vacuoles: A vacuole is a membrane-bound organelle which is present in all plant and fungal cells and some protist, animal and bacterial cells. Vacuoles are essentially enclosed compartments which are filled with water containing inorganic and organic molecules including enzymes in solution, though in certain cases they may contain solids which have been engulfed. Vacuoles are formed by the fusion of multiple membrane vesicles and are effectively just larger forms of these. The organelle has no basic shape or size; its structure varies according to the needs of the cell.

Validly Published: (Reference to publishing a new species). Please see http://www.imafungus.org/Issue/2/13.pdf

Var.: Variety. In botanical nomenclature, variety (abbreviated var.; in Latin: varietas) is a taxonomic rank below that of species: as such, it gets a three-part infraspecific name. This is also known as "sub-species" and is used to describe a consistently appearing variation of a particular mushroom species.

var. nov.: New variety.

Vector NTI: Vector NTI is a bioinformatics software package. A tool for manipulation of DNA data and mushroom identification through comparing sequences of personally collected specimens with those available in GenBank.

Vegetative Hyphae (Vegetative Mycelium): The portion of the mycelium that anchors the mushroom body and absorbs nutrients.

Veil: Protective layer of tissue enclosing the emerging fruit body, which ruptures and disperses (sometimes leaving various remnants). Referring either to the partial veil which joins the stem to the cap edge at first, and often breaks to leave a ring on stem and remnants hanging from the cap margin, or the

universal veil which initially covers the whole fruiting body including the top of the cap, always breaking and sometimes leaving fragments on the cap or the stem, or a volva at the base of the stem.

Velangiocarpous (Synonymous with Velangiocarpic): Spores and gill tissue are protected (concealed) by a veil until the spores have reached maturity. The four types of velangiocarpic systems are monovelangiocarpic (having a single universal veil protecting the primordia), paravelangiocarpic (having a diminished veil oftentimes lost at maturity), bivelangiocarpic (having both an inner partial veil and an enveloping universal veil), and metavelangiocarpic (in which secondary tissues emerge from the cap and/or stem forming an analogue to the universal veil).

Velar: Relating to the veil.

Velar Cells: Cells that compose the veil.

Velum: Outer veil.

Venose: Covered with veins or similar ridges.

Ventral Side: The convex side of a spore which faces away or outward from the imaginary axis of the basidium is called "abaxial side" or the ventral side.

Ventricose: 1. Wider in the middle. 2. With convex lamella edge.

Ventricose-Rostrate: Cystidia in which the basal and middle portions are ventricose and the apex is extended into a beak-like protrusion.

Vermiform: Shaped like a worm.

Verrucose: Term to describe a spore's ornamentation. Warty-roughened, not the same as nodulose.

Verruculose: With moderate outgrowths smaller than if verrucose.

Versiform: With various shapes. Variable in shape.

Very Broadly Fusiform: Spores fusiform with l/w or l/b =1.15-1.5. Cystidia fusiform with Q < 1.5.

Vesicle (Pl. Vesicles): In cell biology, a vesicle is a small bubble within a cell, and thus a type of organelle. Enclosed by lipid bilayer, vesicles can form naturally, for example, during endocytosis. Alternatively, they may be prepared artificially, when they are called liposomes. If there is only one phospholipid bilayer, they are called unilamellar vesicles; otherwise they are called multilamellar. The membrane enclosing the vesicle is similar to that of the plasma membrane, and vesicles can fuse with the plasma membrane to release their contents outside of the cell. Vesicles can also fuse with other organelles within the cell. Vesicles perform a variety of functions. Because it is separated from the cytosol, the inside of the vesicle can be made to be different from the cytosolic environment. For this reason, vesicles are a basic tool used by the cell for organizing cellular substances. Vesicles are involved in metabolism, transport, buoyancy control, and enzyme storage. They can also act as chemical reaction chambers.

Vesiculate (Synonymous with Vesiculose): Cell swollen or appearing inflated like a large sac or bladder (vesicle), with only the base abruptly tapered.

Vessel Hyphae: Wide, empty hyphae cells.

Vestige: A rudimentary or degenerate, usually nonfunctioning, structure that is the remnant of an organ or part that was fully developed or functioning in a preceding generation or an earlier stage of development.

Vesture (Stipe Vesture): 1. To cloth or cover; a covering or garment. 2. (Stipe Vesture) A roughened surface of the tem of a mushroom, usually caused by small cellular projections.

Villose: Pileus or stipe surface is bearing long, hair-like appendages.

Virgate: Pileus or stipe surface is streaked.

Viscid: Pileus or stipe surface is sticky, glutinous, or gelatinous.

Vinaceous: Having a red wine color to it.

Viz.: In contradistinction to i.e. and e.g., viz. is used to indicate a detailed description of something stated before, and when it precedes a list of group members, it implies (near) completeness. Viz. is usually read aloud as "that is", "namely", or "to wit", but is sometimes pronounced as it is spelt, viz.

Volva: A sac-like structure formed at the base of a stipe, such as that found in Amanita species.

Voucher Number: A number assigned to a voucher specimen or collection by an herbarium or organization. Mushroom Observer observation numbers could be considered a voucher number for the MO database.

Voucher Specimen (Vouchered Herbarium Specimen): A voucher specimen is one or more specimens collected and properly submitted to an herbarium (or organization) for storage and further study. Voucher specimens can be examined long after a study has been completed. They enable others to confirm your taxonomic conclusion. Voucher specimens are dried fruiting bodies from the collections that form the basis of the descriptions or additional data associated with a species. They are permanently stored in a herbarium where researchers can access and study them. Researchers can re-examine these specimens and check or amend the descriptions as needed. This is very important because species concepts are often modified through time as new data is obtained.

Warts: Pieces of tissue adorning a mushroom's cap, resulting from the deterioration of a universal veil, as seen in *Amanita muscaria*. Constrast warts with scales.

Warty (Synonymous with Verrucose): With warts; or with outgrowths smaller than if warted but larger than if verruculose (warty includes verrucose and verruculose).

Width: (Of spores) as seen in side view, the largest distance between sides.

Wild Type (Abbreviated wt): The phenotype of the typical form of a species as it occurs in nature.

Wrinkled: Rugose, rugosissimus, rugula, rugulose. Currugated. Formed of alternate ridges and grooves.

Xylophilic (Xylophile, Xylophiles): Wood-loving fungi. Fungi that grow from wood and wood-based products.

Zonate: 1. Having a band-like region darker in color or different than the surrounding tissue. 2. Having alternate areas (usually concentric) of either a lighter or darker color or possessing a smooth and rough surface.

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