How to Grow Your Own Mushroom Spawn

A Step-by-Step Guide to Do-It-Yourself Spawn Kits

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Dear Fungaian,

What a joy! You are a symbiont with the mycosphere.

This guide offers some general information about mushroom cultivation, and outlines the process of using a liquid culture syringe to grow your own mushroom spawn at home.

Hopefully this gets you started, but if you are new to mushroom cultivation and wish to pursue it further, the best first step is to invest in some well-rounded literature on the topic. Two great books filled with indispensable information for do-it-yourself mushroom growers are Organic Mushroom Farming and Mycoremediation by Tradd Cotter and Radical Mycology by Peter McCoy.

I can't tell you how much I appreciate your work to foster fungi and your support of Fungaia. The world could use a lot more people like you.

Mush love!

Do-It-Yourself Spawn Kits

Fungaia provides a variety of do-it-yourself mushroom spawn kits to suit each person's goals, resources, budget and level of experience. Mix-and-match these products with the liquid culture of your choice for a "choose your own adventure" approach to mushroom cultivation.

The instructions for each of these kits is combined into one guide. Use this chart and the table of contents to find the sections that are relevant to your project.

Product	*Chapter(s)*	*Page(s)*
Liquid Culture	**3 & 10**	**9 & 25**
Mushroom Grow Bag Kit	**8**	**22**
Raw / Premix Spawn Kits 10 lb. Raw Organic Rye Grain Spawn Kit 8 lb. Organic Mushroom Substrate Dry Premix - Sawdust Plus for Wood Lovers - Faux Compost for Dirt Lovers	**7 - 11**	**15**
Pre-Sterilized Spawn Kits 7 lb. Sterilized Organic Rye Grain Spawn Kit 7 lb. All-in-One Sterilized Organic Mushroom Spawn Kit Plug Spawn Kit (250pcs/1,000pcs)	**10 & 11**	**25**

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1. A Crash-Course in Mycology

Mycology is the study of fungi. Some of the most adaptive and versatile organisms in the universe, fungi are a backbone of the biosphere and a cornerstone of civilization. As decomposers, they are the architects of succession, playing vital roles in the continuity of the cycles of life. Though they are intimately involved in nearly every living system, the intricacies of fungal ecology are still largely shrouded in mystery.

Mushrooms have been prized for their flavor, nutrition and medicinal benefit by nearly every culture in human history. The word "mushroom" is often used in a general sense to describe a fungus, but strictly speaking, a mushroom is actually an ephemeral *fruiting body,* a growth produced by a fungus for the purpose of reproduction.

While mushrooms usually emerge aboveground, the majority of the organism remains under the surface, or invisibly intermingled with plants. The bulk of a multicellular fungus is called *mycelium*. Mycelium is a dense network of microscopic cellular fibers, called *hyphae*. A single hypha is too small to see without a microscope, but when many are woven together to create mycelium, the fibers can be easily observed, often forming dense dendritic ribbons or cloud-like cottony tufts.

Most fungi reproduce both sexually and asexually. Asexually, they grow vegetatively, much like a tree that produces new shoots from its root structure. Sexually, fungi reproduce by *spore*. Spores are to mushrooms what seeds are to most plants. Each one is a single cell, and so small and light that it

can travel on the wind and germinate far away from its parent. Spores are everywhere, in every corner of the Earth, and every breath we breathe.

Encompassing everything from tiny yeasts and molds to the largest organisms in the world, the Queendom Fungi is vast. Fungal taxonomy is complex and hotly debated among geneticists. To keep things simple, we'll just focus on one phylum, the Basidiomycota, which comprises most of the culinary mushrooms we know and love.

These fungi have a remarkable life cycle. When they produce spores, each one is haploid, meaning it carries half of the genetic information required for reproduction. Much like a seed, it just needs a bit of warmth and moisture to germinate. All on its own, it begins to grow and explore its environment, but remains feeble and is not likely to survive unless it finds a compatible mate, usually a sister spore from the same parent.

In a process known as plasmogamy, the hyphae grown from these two haploid spores fuses together and the nuclei are exchanged between cells. Unlike most eukaryotes (like plants and people), these nuclei can remain separate, co-inhabiting each cell, throughout much of the life of the fungus.

Invigorated by the partnership, this *dikaryotic* mycelium of the fused haploid hyphae can grow asexually for years or even centuries, forming numerous relationships with plants, animals, insects, microorganisms and with larger *common mycelial networks*.

When the right conditions arise, such as after a thunderstorm during a shift of seasons, the mycelium will rapidly redirect huge amounts of its biomass and metabolic energy toward reproduction. Beginning as tiny *primordia*, in a matter of days mushrooms emerge, then mature, sporulate and decompose—that is, if a savvy forager doesn't get to them first!

2. Mushroom Cultivation Basics

Mushroom cultivation is a form of symbiosis. The cultivator sets the scene for fungal reproduction, and in return receives beneficial food-medicine.

There are many approaches to mushroom cultivation, which can be loosely grouped into two categories:

(a) *Outdoor cultivation* involves a variety of techniques for propagating mushrooms in the wild, such as with logs, tree stumps or beds. Many of these techniques are highly scalable, allowing for a high-volume, hands-off approach, but usually the yield is less consistent than with indoor techniques.

(b) *Indoor cultivation* involves raising fungi in discrete containers like bags, trays and plastic columns. This way they can be sheltered from the chaotic whims of Nature and given the greatest possible chances of producing mushrooms and reaching maximum biological efficiency. However, without the constant checks-and-balances of a diverse natural ecology, these controlled environments are more susceptible to invasion by uninvited guests like mold, bacteria and yeast.

The basic process is simple. It begins with introducing either the spores or the mycelium (called a *culture*) of a chosen fungus into a prepared *substrate*, a mixture of the species' preferred food, such as grain, hardwood or manure. This is called *inoculation*. The inoculated substrate is *incubated* until fully grown, then it is either used to inoculate more substrate (called *spawning*), or else it is given a careful balance of light, humidity, warmth and airflow to encourage mushroom formation.

There are many different strategies for inducing mushroom formation, or "fructification." Some species require very specific environmental triggers,

while others reproduce prolifically with indifference to circumstance. The general idea is to simulate the events that precede fungal reproduction in the wild. One common technique is to fluctuate the ambient temperature much like the first deep chill of autumn, which small-scale mushroom growers do by simply placing the mycelium in a refrigerator overnight.

Another technique used widely in the shiitake industry is to apply a brief, high-voltage jolt of electricity, simulating the lightning that often attends a good rain. Though the underlying electro-biochemical mechanisms that make this work are not yet fully understood, it works nonetheless, and is remarkably effective.

One of the natural mushroom-formation triggers most relevant to indoor growers is that mycelium will usually seek to produce spores when it senses it is running out of food and space. The other primary factors needed to induce mushroom formation are light, humidity and airflow.

Regardless of the overall mushroom cultivation strategy, most techniques begin with making spawn. The most approachable, efficient, reliable, and affordable way to make your own spawn at home is with a liquid culture syringe.

3. Liquid Culture

What Is Liquid Culture?

Mushroom spores are like seeds: each one is different. *Liquid culture*, on the other hand, is the pure, living mycelium of a single isolated fungal strain.

A good analogy is with apples: if you plant an apple seed, the chances are 10,000 to 1 that you will get sweet, tasty fruit. This is why apples grown for food are always *cloned*. A clone is genetically identical to its "mother," and retains the particular qualities of the fruit.

Mushrooms are often grown from spores, which leads to a remarkable amount of genetic variability. This is great for their long-term vitality, but the results are unreliable. When a desirable culture is identified and isolated from innumerable possible spore combinations, it can be cloned indefinitely and raised to maturity with consistent success.

Typically, the cloning process takes place in petri dishes in a sterile laboratory setting. A single petri dish can be expanded by many orders of magnitude, and ultimately give rise to thousands of pounds of mushrooms and billions of new spores.

The most efficient way to expand a mushroom culture for cultivation is to make liquid culture: a single clone is fragmented in a nutritive broth and fermented with constant, vigorous agitation. The result is a dense slurry of tiny, free-floating clusters of cells.

When added to a prepared substrate like sterilized grain, sawdust or manure, this liquid creates thousands of distinct points of simultaneous initial growth. Invisible for the first days, the mycelium rapidly expands, finds its genetically identical counterparts, and fuses back into a single organism. To the observer it appears to suddenly explode into life.

Using a Liquid Culture Syringe

Liquid culture is packaged in a syringe for safe transport, storage and ease of use. If kept sealed in the refrigerator, it can remain viable for several months.

For the most part, syringes are used to inject the liquid culture into a sterile environment, such as a jar or mushroom bag, outfitted with a sterile injection port to prevent the entrance of other microorganisms.

Create a clean workspace, free of drafty air. Wash your hands thoroughly. Use an alcohol swab to wipe the injection port on your jar or bag of sterilized material and sanitize the surrounding surfaces. It's best to perform the inoculation quickly to provide the smallest possible window for ambient spores to find their way into the nutritious substrate.

Shake up the contents of the syringe. Peel open the top of the sterile needle package, unscrew the syringe cap, and quickly twist the needle onto the syringe without touching it directly, if possible. Remove the cover from the needle and gently insert it through the center of the rubber plug into the bag. Careful, the needle is extremely sharp.

Steadily inject the contents of the syringe into the jar or bag, distributing the liquid over the contents. The more you add to each container, the more quickly the mycelium will "leap off," but you can also stretch it pretty thin, using only 1-2 mL per quart jar and 4-5 mL per 4 lb. bag. Remove the needle gently. Wipe the injection port with the alcohol swab again, let it dry, and place a piece of tape over it for good measure. Gently shake the container around to distribute the liquid culture.

As long as the liquid culture syringe and needle stay tightly sealed, they should remain sterile. If you want to use part of the culture and then store the rest for later, it's worth going through a little extra trouble: wear gloves, sanitize surfaces thoroughly and work quickly to reduce the chances of

contamination. Set the syringe cap on its side on a sanitized surface and replace it immediately. Rinse the used needle with water, and be sure to sterilize it before using it again.

Consider building or buying an alcohol lamp. The rising heat of a clean "working flame" creates a small, semi-sterile environment around it for inoculation. You can also use it to flame-sterilize a used needle. For best results, get the needle red hot, dunk it in alcohol for a few seconds, then pass it over the flame again to burn it off.

4. Types of Mushroom Spawn

Grain spawn is the most common type of mushroom spawn. Grains are an ideal food source for many organisms, including humans and fungi, because they contain a dense assortment of all the nutrients that a plant needs to germinate and grow. The nutritious pith of the grain is surrounded by a woody hull that protects it from bacteria and yeast, but mycelium, with its robust metabolic prowess, can easily penetrate and digest it.

When saturated with water, sterilized and then inoculated with mushroom spores or cultures, each individual grain becomes a foothold for the developing fungus, which uses the stored food to sustain its exploration of the surrounding environment.

One great advantage of grain spawn is that it can be easily broken-up and distributed throughout a bulk substrate like sawdust, where each grain becomes a self-sufficient satellite colony to support the mycelium's rapid expansion.

Sawdust spawn is the preferred choice for many outdoor mushroom cultivation techniques. Sprinkled in layers with cardboard over a wide area, or

packed into holes drilled in freshly cut wood, a successful inoculation can produce large flushes of mushrooms multiple times per year (depending on the species) and, if matched to the climate and well-maintained, can overwinter and continue growing and reproducing for years. It is also an ideal medium for spawning sterilized, nutrified wood-based fruiting blocks and other bulk substrates for indoor cultivation.

It is usually made using hardwood sawdust, as coniferous woods are too resinous for most gourmet mushroom species to handle. It is hydrated, sterilized or pasteurized, and inoculated using grain spawn. When supplemented with nitrogen-rich ingredients like bran or worm castings, it can be used as a stand-alone substrate for most wood-loving mushroom species.

Plug spawn (or **dowel spawn**) is used to inoculate hardwood logs and stumps. Usually, sterilized hardwood dowels are inoculated with grain spawn and incubated until the mycelium has fully engulfed them. After drilling numerous holes in the wood, the dowels are tapped in and sealed with wax. Logs can then be stacked in piles or columns or nested into a “raft-style” mushroom bed.

5. Sterility: Why All the Fuss?

The basic principle of mushroom cultivation is to create the ideal environment and then let the mycelium weave its magic. But there are many, many organisms that thrive in the same conditions, and not all of them are friendly. The most surefire way to grow a particular, desirable fungus is to give it a running start in a sterile environment.

Like most organisms, a fungus is delicate and vulnerable during the earliest stages of its growth. Once it "grows up" and achieves a sufficient biomass, it has a remarkable array of biochemical tools to ensure its survival. Making sterile spawn may seem like a lot of fuss, but the reward is well worth the trouble.

Liquid culture is prepared under strictly sterile conditions. By using a cropping container outfitted with a "self-healing injection port," you can inject the culture into a sterile environment without opening it, foregoing expensive laboratory equipment.

6. Goof and Grow: A Note about Failure

When researching mushroom cultivation, newcomers to the field are often wooed and wowed with pictures of big beautiful mushrooms and abundant harvests, and there is a tacit conspiracy among professionals to make it look easy. It is not.

Mushroom cultivation involves numerous intricate steps, and in each one there is plenty of room for error. More art than science, it is a practice which requires foresight and intuition. Like any creative enterprise, failure is an inevitable part of the process.

Our culture instills in us an expectation of consistent success. There are specialists in every trade, if not masters, and we learn to leave the heavy lifting to the professionals. One of the great tragedies of this cultural landscape is that it discourages experimentation.

If everything were to work out just as we expect, what would be the point of trying? We are not automata, and neither are our fungal friends. It is too seldom said that any healthy, balanced approach to trying something new requires the acceptance of possible failure. Nothing can sap a passionate enthusiasm faster than disappointment, but taking strides in a new direction will always yield positive results, even if they are not readily apparent.

There is no shorter path to discovery, wisdom and joy than embracing uncertainty and trying something new. So hope for the best, prepare for the worst, and venture forth. To fail, and try again, and again—that is success.

II. Preparing and Sterilizing Spawn: Step-by-Step Instructions

There are many tried-and-true techniques for growing mushrooms, but some are more reliable than others. The easiest approach for the beginner is to purchase an all-in-one, pre-sterilized grow bag of mushroom substrate with an injection port, available from the Fungaia shop and a variety of other online sellers. The most affordable approach, especially if you intend to make a routine of it, is to prepare it yourself.

Here is a very basic primer on preparing your own spawn. First you'll need (1) a sterilizer, (2) a good cropping container, and (3) some hearty mushroom food:

(1) The best way to achieve sterility is with heat. Some mold spores can survive even in boiling water, so you'll need a pressure cooker to reach a high enough temperature to destroy them, about 250ºF (120ºC). Pressure cookers can be dangerous, so make sure you use caution and closely follow the manufacturer's guidelines.

(2) Mycelium needs oxygen, so your container needs to allow for air exchange. The two most common cropping containers are mushroom bags and mason jars.

Nearly all commercial mushroom producers use polypropylene filter-patch bags specifically engineered for mushroom cultivation. Like jars, these bags can also be modified for home use. Grow bag kits can be added to any

purchase from the Fungaia shop for a $1 suggested donation. (If you purchased one with this order, see the instructions below.)

Mason jars are used with a modified "airport" lid. You can purchase these lids from other vendors or make them yourself (a quick YouTube search will turn up lots of great how-to videos). The cheapest option is to drill two 1/4-inch holes in the mason jar lid. Stuff one tightly with polyester fiberfill to make an air filter, and coat the other on both sides with a thick blob of silicone to make your injection port.

(3) The most common type of spawn is grain spawn. Other common substrate ingredients include hardwood sawdust, wood chips, straw, cardboard, compost and manure. The next few sections will describe how to prepare your chosen spawn type.

7. Preparing your Own Spawn

Fungi are the great decomposers of biological matter, and are known for their ability to figure out how to digest just about anything, especially wood lignin and cellulose. In general, the edible mushroom species used in cultivation can be grouped into two categories, the primary decomposers that thrive on wood-based substrates, and the secondary decomposers that prefer compost and manure.

Different varieties have different preferences, and some are pickier eaters than others. But the basic parts of a substrate recipe are usually the same: a balance of carbon, nitrogen, minerals, and trace nutrients. Water is the most important ingredient of all; since mushrooms, like people, are mostly made of the stuff, a properly hydrated substrate is key to producing a good crop.

Grain Spawn

I prefer rye, but any whole, unhulled grain or seed will work. Bird seed, oats, brown rice and millet are also popular choices. Perfect grain spawn is fully saturated with water but dry to the touch, with few to no broken kernels.

Here's my method:

Soak the grain for 12-24 hours. It will nearly double in volume, so add enough cold water (preferably filtered) to keep them covered. Not only does this step ensure complete saturation, it also initiates the enzymatic process of germination inside the grain, allowing the mycelium to quickly access the stored nutrients. It also helps to prevent grains from bursting in the sterilizer, and germinates heat-tolerant bacterial endospores, which are then readily destroyed by the hot steam.

Many folks like to supplement the soak with minerals and nutrients. Adding a spoonful of gypsum is a common recommendation. You can also experiment with using things like leftover pasta water, spent coffee grounds, or a scoop of the bulk substrate mixture you plan to use later on.

Next, you'll want to dry the grain. Excess water in your jars or bags creates soggy conditions that are challenging for the aerobic mycelium, it encourages contamination and it leads to clumping. When fully hydrated, there is plenty of water trapped inside the grain for the mycelium to grow.

Drain the grain in a pasta strainer and keep the water. In a large pot over high heat, bring this water to a rolling boil. Add the grains and gently stir for a few minutes, until the water just begins to boil again. Promptly drain the grain. The idea is simply to get it steaming hot, not actually cook it. Over-cooked grain tends to burst, exposing the starchy pith and encouraging undesirable bacteria and yeast.

Gently shake the colander over the sink to drain off all of the water, then spread it out over a wide surface. This allows the surface moisture to steam off completely. You can spread it on a clean towel, cloth, or paper, or you can use a window screen or dehydrator rack—anything that allows you to fully release all of the moisture while the grain is still hot. For small batches, simply shaking it around in the pasta strainer for a few minutes usually does the trick.

If you are using jars, only fill them about 2/3 full to leave room for shaking the grain to mix it, which accelerates incubation. Wipe off the rim and threads, screw on the modified lids, and cover each one with a piece of aluminum foil before loading it in the pressure cooker.

Plug Spawn (Dowels)

If you have space and access to hardwood logs or stumps, a fantastic method for low-tech, cost-effective mushroom farming is dowelling. Find pre-sterilized plug spawn kits in the Fungaia shop, and see the "Next Steps" section below for instructions for this technique.

You can purchase dowel pins from cabinetry and woodcraft suppliers. Spiral-groove dowels are preferable to the fluted variety. These are usually made from hardwoods like birch and poplar, but it can't hurt to call and check.

Dowels are usually hydrated, sterilized and inoculated with grain spawn. The simplest method for producing them yourself is to make all-in-one bags or jars, combining prepared grain and dowels in the same container, then inoculating them with liquid culture.

To do this, you'll only need a small amount of grain: measure out about ½ cup grain per pound of dowels (dry) and prepare it according to the instructions above. As you soak the grain, put your dowels in a ziploc bag and

cover them with clean water. If you like, you can add soak supplements like gypsum just as you would for grain. Press all the air out of the bag and seal it shut. This keeps them fully submerged; otherwise, they will float up above the water and not absorb enough water.

Place the bag in a bowl or dish, in case it leaks, to soak overnight. The next day, drain the dowels in a colander or pasta strainer for several minutes (heating them is unnecessary), add them to your jars or bags, then pour the grain over the top and sterilize, cool and inoculate them as you would grain spawn, according to the instructions below.

Sawdust spawn

Typically, wood-lovers are grown on sawdust that is inoculated with grain spawn. On its own, there are few things besides mycelium that can eat raw wood, so sterilization is not strictly necessary, and some cultivators simply hydrate sawdust and mix it immediately with a large proportion of mature grain spawn. More often, it is pasteurized using something resembling a giant vegetable steamer or "cold pasteurized" with alkaline water.

The most common, time-tested technique, however, is to supplement the plain sawdust with additional nutrients, especially nitrogen-rich ingredients, to maximize the productivity of the fungus and reach maximum biological efficiency. The vast majority of commercial gourmet mushroom growers use this technique. There are trade-offs, though: the supplementation makes the substrate far more attractive to undesirable microorganisms like yeast, mold and bacteria, so complete sterility is a must.

With the use of a wonderful but large and costly piece of laboratory equipment called a *laminar flow hood*, grain spawn can be transferred to supplemented sawdust under totally sterile conditions. For the beginner and small-scale cultivator, the next best thing is to combine the grain and bulk substrate in a single "all-in-one" container, making it possible to bypass the

transfer and avoid this sensitive step altogether. This technique is outlined in the next section.

A convenient and reliable source of hardwood sawdust are the fuel pellets sold at hardware and farm supply stores for pellet stoves and smokers. These pellets are a byproduct of timber and pulp milling, and are kiln-dried and tightly compacted. Sawdust is often combined with wood chips in equal proportions. Mills, carpentry and cabinet shops and arborists are also great resources for substrate ingredients.

Some common ingredients for nitrogen supplementation are wheat bran (15-20% by dry weight), soy hulls (up to 50%), spent coffee grounds (15-20%) and chicken manure (10%). My personal favorite is worm castings (10%), as worms and fungi are good friends. (For a beautiful, space-efficient, biodynamic permaculture system, start a worm farm. The castings will feed your mushrooms and plants, and in exchange you can feed the exhausted mushroom substrates and garden wastes back to the worms.)

Generally speaking, mycelium prefers a higher pH (less acidic) than other soil-dwelling microbes. Adding a mineral supplement helps buffer the pH and lowers rates of contamination. Gypsum is the go-to in the industry (added at about 3-5%). If you are using acidic supplements like coffee grounds or chicken manure, you can add a small proportion of lime (0.5%) or potash (1-2%). Use a litmus test for best results: a neutral to slightly alkaline formula is best.

A very basic but effective recipe, by weight, is 10 parts sawdust pellets, 10 parts wood chips, 1 part wheat bran and 1 part gypsum. Other great substrate ingredients are charcoal/biochar, straw and cardboard. Check out the books on page 1 for more information on substrate formulation.

Like the grain, it helps to first fully hydrate your substrate overnight. Mix your ingredients in a large container, then heat a pot of water to at least 150ºF

(65ºC). Pour it over the wood pellet mixture, a little at a time, and watch as it nearly quadruples in volume.

Achieving an ideal moisture content is essential: too dry and your yield will suffer; too wet and bacteria will predominate. The difference between the two is often a matter of just a small amount of water. Mix the substrate, grab a handful, and squeeze. If you see more than a trickle, it's too wet, and you'll need to either drain it, add more sawdust, or both. If you squeeze with all your might and hardly see a drop, it needs more. Water collecting in the bottom of the container is a sign of over-saturation. Hardwood pellets that have not fully disintegrated indicate it is too dry.

Make Your Own All-in-One Kit

As described in the previous section, you can combine two steps of the standard cultivation process into one by making an all-in-one kit. Follow the steps outlined above to create separate batches of grain spawn and sawdust substrate. First, fill your bag or jar with the sawdust mixture and lightly compact it, creating a shallow indentation on the top, then pour the grain over it. Only fill your jars about two-thirds full. If using bags, read the following section for some important tips.

8. The Mushroom Grow Bag Kit

Ubiquitous throughout the gourmet mushroom industry, these specialized spawn bags are the biggest thing since sliced bread. If you're new to using mushroom bags, there are some things you need to know.

These bags are sterilizable, reusable, recyclable, sturdy, flexible, transparent, affordable, disposable (in the event of severe contamination), inert (food-safe) and they double the efficiency of sterilization and storage compared with jars. While plastic is still plastic, all these benefits make mushroom bags the perfect vessel for both small and large-scale mushroom cultivation.

This kit includes one large grow bag with all the little pieces you need to use them in a pressure cooker at home: a large, 3 mil polypropylene grow bag with 0.2 micron filter, a sterile injection port for use with a liquid culture syringe, twist-ties for sealing the bag without a heat sealer, a piece of twine to keep it from sealing itself shut during sterilization, and some tape to cover the injection port after inoculation.

Fill the bag about halfway. Headspace is important. About 4-6 pounds of grain and/or substrate is the norm, and 8 pounds is about the maximum. After filling, wipe off any material that stuck to the sides within a few inches of the top.

The bag will often stick to itself in the heat, so the twine acts as a vent if any pressure accumulates during sterilization. Stick one end of the twine into the contents and drape the other end out of the opening. Twist the top, above the filter, and use a twist tie to hold it loosely closed so steam can escape.

The bag is outfitted with a self-adhesive rubber injection port.[1] The heat of sterilization will activate a sturdy bond between the plastics, but be careful not to knock it off the bag before it goes in the pressure cooker. Afterward, inoculate with your syringe and cover the port with the included clear tape.

Never seal bags before placing them in a pressure cooker. As the pressure drops during venting or cool-down, the bags can inflate. If they block the steam vent, the cooker can over-pressurize and, in the worst-case scenario, explode. Yikes!

For best results, seal the bags promptly after sterilization, while they are still hot. A few minutes after it fully depressurizes, open the sterilizer and allow the steam to dissipate. Remove the piece of twine from each bag with a few short, gentle tugs. Twist the top another turn and tighten the twist tie. Fold the bag down from this first tie, then wrap the second twist tie around this loop for a durable, airtight seal. Make sure the filter still has room to breathe. (If you have sensitive hands, use thick gloves when handling hot things!)

You can usually reuse each bag 5-6 times before it must be retired. In the event of contamination, it is best to discard the unopened bag. Otherwise, simply rinse it (or you can wash it out with gentle soap and water), fluff it up and prop it upside-down to drain. Let it dry completely, then store it for reuse. Once sterilized again, it will still work like a charm.

[1] After conducting countless experiments, testing every available product and DIY technique I could find, this proved both the most effective and the most affordable. Many folks forego the injection port altogether, and simply put a piece of clear packing tape on the bag, inject the culture syringe through it, and quickly cover the hole with a second piece of tape.

9. Sterilization

Place your bags or jars on a rack in the pressure cooker so they sit above the water. If using multiple bags, leave them ample room for expansion and avoid overfilling the pot.

When using a pressure cooker, always carefully follow the manufacturer's instructions. When in doubt, add more water than you need to avoid running it dry. Once steam begins hissing from the vent, back it off the highest heat and give it 5-10 more minutes to push all of the remaining air out of the cooker, leaving only steam, before closing the petcock and allowing it to build pressure. Never leave a pressure cooker unattended.

Sterilize at a full 15 psi (250ºF/120ºC) for 90 minutes for grain spawn and 2 hours for denser substrates and all-in-one kits. Always allow the pressure cooker to completely depressurize before opening it.

As the pressure cooker cools, the steam will condense back into water and it will begin to draw a vacuum. Some cookers will gradually draw air inside, while others will hold this vacuum for a long time, which means when you finally release the petcock they will quickly suck up lots of dirty outside air at once.

If you're using bags, seal them hot, as described in the previous section. If using jars with filtered lids, leave the pressure cooker alone until it has cooled completely. Very few spores will be intrepid (or lucky) enough to venture all the way through the vent, under the foil, through the filter and into your grain.

III. Growing Spawn

10. Inoculation

Create a clean workspace, free of drafty air. Wash your hands thoroughly. Place the bag of sterilized substrate upright with the injection port facing toward you. (If you ordered a large all-in-one substrate block, leave it in the box.) Wipe the surface of the injection port with an alcohol swab to sanitize it.

It's best to perform the inoculation quickly to provide the smallest possible window for ambient spores to find their way into the nutritious substrate. Shake up the contents of the syringe. Peel open the top of the sterile needle package, unscrew the syringe cap, and quickly twist the needle onto the syringe without touching it directly, if possible. Remove the cover from the needle and gently insert it through the center of the injection port. The needle is extremely sharp, so take care not to tear any holes in the plastic, or yourself.

Steadily inject the contents of the syringe into the jar or bag, distributing the liquid across the surface of the grain. The more you add to each container, the more quickly the mycelium will "leap off," but you can also stretch it pretty thin, using only 1-2 mL per quart jar and 4-5 mL per 4 lb. bag. Remove the needle gently to avoid peeling the rubber. Wipe the injection port with the alcohol swab again, let it dry, and place a piece of tape over it for good measure.

Gently shake the grain around to distribute the liquid culture. If using an all-in-one kit, avoid breaking up and mixing the block just yet.

A single liquid culture syringe can be portioned out a little at a time and stored for future use. In this case, extra care must be taken to avoid

contamination down the road: wear gloves, sanitize surfaces thoroughly and work quickly. Set the syringe cap on its side on a sanitized surface and replace it immediately after the inoculation. After being opened, the needle will need to be resterilized before reuse.

Consider building or buying an alcohol lamp. The rising heat of a clean "working flame" creates a small, semi-sterile environment around it for inoculation. You can also use it to flame-sterilize a used needle. For best results, get the needle red hot, dunk it in alcohol for a few seconds, then pass it over the flame again to burn it off.

11. Incubation

Stand bags upright, with the air filter patch on top, in a warm place. 68-75ºF (20-24ºC) is ideal; much warmer than 90ºF (32ºC) can cook the mycelium, and below about 55ºF (13ºC) growth is slowed and can stall. Light is harmless but unnecessary during this phase of growth, and tends to encourage premature mushroom development. Avoid direct sunlight.

A perfect place for incubation, if you are lucky enough to have one, is the cabinet above the refrigerator. Any comfortably warm, accessible and out-of-the-way place will do.

Growth should be visible within a few days, first appearing as little white tufts that expand and begin to interconnect. You can gently shake the grains around to mix them up once or twice during this first stage to accelerate growth, but allow the mycelium to get comfortable with the grains before breaking up the whole substrate block.

After about 5-10 days, once the mycelium is visibly growing on a good portion of the grain, it's time to break up the block. Mixing the substrate disperses the incubating mycelium and allows it to grow quickly and evenly.

Lay the bag on the counter and gently but firmly loosen, break up and spread the contents along the length of the bag. Shake it up and down, turn it over, wiggle it around and whisper sweet nothings in its ear. Mashing the mycelium too aggressively or too often may be harmful, but disturbing it in this way invigorates and stimulates its growth. The goal is to mix the substrate thoroughly, evenly and with benevolent intentions.

Once mixed, grab the top of the bag and tap it on the counter a few times to settle the grain and/or substrate back to the bottom. Gently compress it back into a block so the mycelium can easily leap from one particle to the next. Flick the air filter and upper corners to shake off anything that might have stuck there, then put the bag back in its happy place and watch as the mycelium proliferates.

With grain spawn or small containers of substrate, one thorough mixing is usually sufficient. Otherwise, repeat this break-and-shake after about 5-10 more days to ensure even growth, and encourage the fungus to explore the whole block of substrate before it attempts to reproduce.

After incubating for 1-2 weeks for grain spawn and about 3-4 weeks for denser substrates, the whole block should be enveloped by white mycelium and is ready to move on to the next phase of its growth. Depending on the species you selected and your intended cultivation strategy, you can now use your spawn to inoculate a bulk substrate like sawdust, wood chips, or straw, or give the mycelium what it needs to begin forming mushrooms.

IV. Next Steps

12. Tips and Tricks for Indoor Mushroom Cultivation

When you think your mycelium is ready to enter its next phase of growth, there are many ways to go about it. A comprehensive treatise is beyond the scope of this guide, but here are some considerations to help point you in the right direction.

Mushrooms need fresh air, plenty of indirect light and lots of moisture to grow best. If you provide these conditions, the fruits will soon follow.

Light: Contrary to common preconceptions, mushrooms need abundant light to grow. Direct sunlight will quickly irradiate and harm raw mycelium, but indirect sunlight or daylight-spectrum indoor grow lights work well to provide the kind of diffuse light found in the shady forest understory where mushrooms typically abound.

Moisture: Usually scarce in the dry seasons, some mushrooms need as much as 95-100% relative humidity during the early, sensitive stages of their growth. Large-scale indoor mushroom growers usually use high-volume mist nozzles or powerful ultrasonic humidifiers to maintain a consistently humid fruiting environment. These conditions are often replicated on a small scale with a handheld spray bottle and/or a closed environment like a plastic bag or storage tub.

Air: Mycelium, like people, requires oxygen and produces carbon dioxide. Without fresh air, it can suffocate. Fine-tuning CO2 levels is one of the most important factors in honing advanced and commercial-scale mushroom cultivation techniques, but for the purposes of the small-scale cultivator, simply ensuring constant or periodic ventilation is sufficient.

Striking a balance between maintaining high humidity and good airflow is one of the main "tricks" of the trade, and while most commercial cultivators rely on complex and high-tech feedback and control mechanisms, there is no substitute for developing a good, intuitive, working understanding of how these factors influence mushroom growth.

There is not a perfect, stable balance to achieve, as nothing in nature is ever so consistent, and mushrooms generally benefit from periodic environmental fluctuations, allowing excess water to evaporate with moving air, then rehydrating, and so on.

Growing Mushrooms from Bags

Most of the commonly cultivated wood-loving mushroom species can be grown directly from mushroom grow bags, including the Oysters (*Pleurotus spp.*), Lion's Mane (*Hericium spp.*), Pioppini (*Agrocybe spp.*), Shiitake family (*Lentinula & Lentinus spp.*) and Reishi (*Ganoderma*). Each has its own quirks and preferences, so it's best to do a little research on how to tend a particular variety. Jars and bottles can also work as cropping containers.

If left alone for long, mushrooms may begin to form in the unopened bag. Carbon dioxide accumulates in the tightly-filtered environment, which causes the mushrooms to grow long stems in search of fresh air. *Ganoderma* species, for example, are usually allowed to develop this way for some time, growing desirable "antlers," before the bag is opened for the final stages of growth.

The simplest and most effective method for growing mushrooms in bags is to make a hole for them to emerge from. With the bag upright, make a small cut in the upper corner to release all the air. Roll the top down tightly and use a piece of tape or some rubber bands to keep it closed.

Place the bag upside-down, holding itself shut. Press it down a bit so it stays upright. Use a box cutter or sharp knife to cut one or two X-shaped slits in the bag, about 2-3 inches (5-8 cm) across.

The mycelium will respond to contact with the air, and over the course of the next few days will begin to emerge from the hole in the bag. First appearing as indistinct lumps, they will grow noticeably from day to day and begin to take shape.

Use a spray bottle or mister to lightly moisten the surface of the bag and the emerging mushrooms 3 or more times per day. The key to great mushrooms is water. Too much moisture can lead to mold and rot, but with too little the mushrooms dry out and stop growing. If they begin to turn brown, this is usually a sign they are too dry.

For the best results, you may need to create a tent or humidity chamber, especially if you live in a dry climate. One easy method is to place the bag of mycelium on a plate, baking pan or similar container and cover it loosely with a plastic bag. Each time you mist the mushrooms, spritz a little in the dish to evaporate slowly.

Some folks construct a miniature hoop-house using stiff wire to prevent the plastic from touching the emerging mushrooms, which otherwise tends to make them slimy. Or you can make a tent using a cardboard box: Tape the flaps together to make tall sides, and drape a piece of clear plastic over the top. This technique works remarkably well, and the opaque box discourages mushrooms from forming inside the bag.

If you think you might pursue mushroom cultivation as a hobby, you might consider building a “shotgun fruiting chamber” or “monotub.” (There are many great YouTube videos about these techniques.)

To do this, you'll want a spacious (e.g. 65 quart), clear plastic container, ideally with a clear lid. Drill two rows of ½-inch (1 cm) holes, spaced about 2 inches (5 cm) apart, all the way around the container: one around the top and the other about 2 inches above the bottom. Drill gently to avoid cracking the plastic. Fill the bottom of the container an inch or so deep with clean, wet sand or perlite, or just add a bit of water.

Adding a capful of hydrogen peroxide to the water each time you replenish it will hinder mold growth. If contamination is a prominent concern in the environment, find a container with an airtight gasketed lid.

You can also create simple air filters by stuffing the holes with polyester fiberfill or covering them on both sides with a layer of Micropore™ tape. This will help keep spores out, boost carbon dioxide levels, and retain humidity. If the mushrooms begin to grow stemmy, this is a sign they need more air. You can add more holes, loosen the fiberfill or experiment with leaving the lid ajar to try to find a good balance between airflow and humidity, which will vary from place to place and season to season.

Open the lid and lightly mist your mushrooms as needed, usually no more than 2-3 times per day. Make sure the bedding also remains damp.

If your mushrooms dry out or stop growing for some reason, you can remove the stalled growth and use clear packaging tape to seal the hole you cut in the bag. Then cut a new one on the other side.

Addressing Contamination

Q: Why did the dirtbag leave the spore party?
A: Because there wasn't mush room.

When attempting to grow mushrooms on sterilized substrate, uninvited guests can easily ruin a good time. In mushroom lingo, "contamination"

refers to the growth of any microorganisms—usually mold, bacteria or yeast—that hinder or harm the cultivated mycelium.

When tending a crop, it is especially important to keep an eye out for mold. A tiny colony can spread quickly, so it's best to nip it in the bud. Hydrogen peroxide is the best treatment, because it destroys spores and single-celled organisms but the mycelium, which naturally produces its own peroxides, will be able to neutralize it. Add several drops of standard household-strength hydrogen peroxide to the mister and give the moldy spot a firm blast. If it fizzes, the peroxide is doing its work.

Next you can attempt to cut away the contaminated area with a clean knife or spoon. Keep an eye on it and repeat this spot treatment if necessary. If it comes back with a vengeance, you may have to discard the substrate and try again. Mold spores can be noxious, especially if you are prone to allergies, but a little bit here and there won't hurt you.

By closely following the techniques outlined in this guide, mold contamination is relatively rare. But mold spores are everywhere, especially in kitchens, and this is where the rubber really meets the road in mushroom cultivation. In the long run, every mushroom cultivator will inevitably encounter these *fungi imperfecti*, so don't let it discourage you when you do. Just take a break, give it some time, go find some wild mushrooms in the forest, and let yourself fall in love with the process again. It will make the fruits of your future success all the sweeter.

Harvesting and Storage

When your mushrooms are mature and ready to harvest, you can simply grasp the whole cluster and twist it free of the mycelium. Some folks prefer to slice it off using a very sharp knife. Either way, be careful not to bruise the remaining portion or you may encourage bacterial decay.

A well-formulated substrate contains enough nutrients to sustain multiple consecutive harvests before the growth slows and the fungus begins to yield to succession. Typically, each harvest, or "flush," is slightly smaller than the last, but it is usually possible to get 3 or 4 rounds before other organisms start to take over. Then the mycelium will need to be moved outside, where it may continue to produce, or it can be mulched into the garden.

Freshly harvested mushrooms retain metabolic heat, and are noticeably warm to the touch. Chilling them rapidly will prolong their shelf life. They sweat, especially as they first cool, and continue to breathe, which is why they are usually stored in the refrigerator in a kraft paper bag. They will readily absorb odors from other stored foods, so another good method is to line any typical food storage container with kraft paper instead. Store-bought mushrooms are also sometimes sold in plastic wrap, but this is actually a specialty, engineered packaging system, and mushrooms wrapped in typical cling wrap will soon turn to mush.

Fresh mushrooms are actually still very much alive. If stored well but left too long, they may "fuzz out" and begin slowly converting their own biomass into new mycelium. They are still safe to eat at this stage, but the texture becomes strange. They may also begin to grow into and digest the paper bag.

Chow

There are countless fantastic recipes for cooking with mushrooms, but sometimes the simplest method is the best way to truly savor the delicacy of the ever-so-well-deserved fruits of your labor:

Using your clean, bare hands, tear the mushrooms into large chunks or slivers. Toss them in a hot skillet over medium heat. Add a dash of water or wine to get the steam going, and put a lid on for a minute or two, until they render their juices. Remove the lid, bump up the heat, and stir, letting the moisture steam off. Then drop in a pad of butter (or a skein of oil), and

perhaps a bit of fresh garlic, and brown them up a bit. They don't need long, and some get chewy when overcooked. Finish them off with a pinch of salt and perhaps a sprinkle of fresh thyme. Pull them quick and eat them hot, with your fingers and your friends, before bothering with any formal meal arrangements.

13. Growing Mushrooms on Stumps and Logs

A Guide to Inoculating with Dowels

Dowelling logs is one of the easiest, most efficient and most rewarding ways to grow your own gourmet mushrooms.

First, you will need the following materials:

- Inoculated dowels
- Logs or stumps
- A drill with a 5/16-inch bit
- A candle or a wax bath and a brush

Step 1: Find some wood

With a little luck and persistence, you can grow mushrooms on nearly anything, but the best chance of a successful inoculation depends on good timing and a thoughtful pairing of the species of mushroom and the type of wood you have access to.

Fresh-sawn wood is a must. Fungal spores are ubiquitous, and as soon as wood is cut they begin to move in. The ideal window for inoculation is within 3-4 weeks, and after about 6 months you can't hope for much out of them. Wood cut from trees with heart-rot may or may not work, depending on how much living tissue is left. If you plan on cutting down a healthy tree, please consider planting a few in its stead to keep the cycle going.

Most gourmet mushroom species prefer the wood of deciduous trees, as conifers are generally too resinous. Oak, maple, and walnut are highly valued because they are dense and can support large crops, sometimes for several years. But these woods can be hard to come by, and the mycelium will eat them slowly. Alder, willow, and cottonwood are all fast-growing trees and support the rapid growth of many different mushroom species. Birch, beech, poplar, ash, aspen, hemlock, fruit woods... I won't give you an exhaustive list here, but if you're hung up on sourcing wood, a good place to start is researching the preferred habitat of the mushroom species you wish to grow.

I'm also (almost) always available by phone if you'd like a second opinion on your plan! In my experience the only real way to find out if something works is to try it. A healthy fungus has an incredibly adaptive appetite.

The best logs are 6-8 inches in diameter and 4 or 5 feet long, or as big as you can comfortably move around. A safe minimum is about 4 inches, and anything over 1 foot diameter is going to need to incubate for a very long time. Don't remove the bark; the fungus will need its protection.

Note: If you don't plan to use your dowels right away, you can stick them in the fridge until the stars align.

Step 2: Drill

Using a 5/16-inch drill bit, make holes roughly to the center of the log on all sides. I'm personally of the mind that the more the merrier, but you can try staggering the holes about as far apart as the log is wide, then see how many dowels you have left at the end.

As you go, frequently back the drill out to remove as much of the sawdust from the hole as possible.

Step 3: Tap

Using a wooden or rubber mallet, tap the dowels into your holes. I like to use a stick or a length of 1/4-inch wooden rod to tamp the first dowels all the way to the bottom of the hole, so that the next ones go in more easily. Stop before you end up with a dowel sticking out of the log.

Step 4: Wax

Sealing the log with wax keeps the moisture and slows the ingress of competitor fungi. Just a drop or two from a candle works fine; it only needs to lightly cover the hole to do its job. Soy wax is preferable to paraffin.

It is also important to seal the cut ends of the log, especially if you live in a relatively dry climate. The candle goes pretty quick on this part, so it can be helpful to have a wax bath and either dip the whole log in it or paint it on with a brush. (I made a simple one using a soup can, coat hanger wire, and a homemade alcohol lamp.)

Step 5: Incubate

Store your inoculated log off the ground. A forklift pallet works great for this. Multiple logs can be stacked criss-cross fashion to make large mushroom towers. If you go this route, think ahead about where the mushrooms will pop out and how you're going to harvest them.

Either place the log somewhere with full shade, or cover it with shade cloth. If it's in the sun, put some cardboard on top for good measure and give it some water from time to time.

If you are inoculating your log in the springtime, it will hopefully produce mushrooms in the fall. If you're starting in the summer, it may help to place your log in a cellar while the mycelium first gets a handle on things. A log started early in the year can usually be left out through the winter, but you'll

want to keep it in a greenhouse if it hasn't had long to grow, or if you live somewhere with extreme cold.

Keep an eye out for mushrooms in the spring and fall, especially after rain. As they emerge, mist them occasionally so they reach their full size without drying out.

14. Starting Outdoor Mushroom Patches

The simplest way to get an outdoor patch going is with sawdust spawn. Once the sawdust is fully incubated in a sterile environment, the mycelium has a sufficient biomass and an impressive array of biochemical tools to defend itself from pathogens and integrate with all the other organisms that live in soil.

Many factors are at play when attempting to establish an outdoor mushroom patch. Climate, soil type and local flora should be taken into account when choosing a mushroom species to work with. The Garden Giant (*Stropharia rugosoannulata*) is one of the most popular choices for integrating into existing gardens and raised planter beds, as it thrives in bacteria-rich topsoil environments.

Start by collecting some big pieces of cardboard. Wood chips, straw, sawdust, charcoal and any other fresh woody material will help too. These materials are usually applied as-is, but you can pasteurize them to increase the chances of success. Steam pasteurization is effective but inefficient. Another great option is "cold pasteurization" with an alkaline soak.

To do this you'll need either potash or lime, and a big, watertight container with a drain, such as a barrel, horse trough, kiddie pool or series of plastic buckets. Potash collected from a wood stove is environmentally friendly and

usually free. Hydrated lime for masonry is sold on the cheap at most hardware stores. The stuff you want is calcium hydroxide, not the calcium carbonate sometimes sold as lime for gardening. (Lime is caustic and can burn your skin. Gloves, goggles and dust mask are strongly encouraged.)

Use about 9 pounds (4 kg) potash or 3/4 pound (300g) of lime per 50 gallons total water.

Fill the soaking tub with your wood chips, straw or whatever you were able to find, then add the potash or lime. Submerge the whole thing in cold water, soak for 12-24 hours, and let it drain. It is ready to apply immediately.

Pick out the site of your future mushroom utopia. You'll want to find a shady spot or put up some shade cloth, as direct sun will cook the bed dry. First, scrape the topsoil aside with a rake or hoe to expose the raw dirt. Keep this topsoil close, because you'll use it at the end to cover the patch.

Some folks like to light a bonfire on the ground first to sterilize and alkalinize the soil, especially when attempting to establish burn-loving morels. Either way, once you have your site prepared, thoroughly hose it down with water and lay down one or two layers of wet cardboard.

Cardboard is ideal because it offers very little food for bacteria, and it creates a barrier to protect the growing mycelium. Mushroom mycelium loves cardboard and will quickly grow horizontally along the corrugations. Soak it for an hour or two first. Some people recommend peeling the layers apart to expose the corrugation.

Next cut open your bag of sawdust spawn and break it up into chunks with clean hands. Scatter a light layer over the cardboard, cover it with your woody matter, and scatter another layer of spawn on top. Cover with another layer of cardboard and repeat this process as many times as your spawn and material allow to make a thick lasagna. Once you have used all your spawn,

place another layer of wet cardboard over the top and cover the whole thing with the topsoil you scraped aside.

Use a stake, long knife or other pointy implement to poke a series of holes to allow water to travel down through the layers.

Keep watering your patch as you would a vegetable garden. Assuming all goes well, you should get your first flush of mushrooms in a few months. If you prepare the bed in the fall, it will hopefully produce the following spring, and then again every spring and fall, ideally for years.

You can keep feeding the patch by adding more layers of straw, wood chips, cardboard and/or sawdust once a year. For best results, make more sawdust spawn from the same original fungal culture and continue spawning the bed. Persistence pays off: a patch which is nurtured continuously for several successive seasons will produce larger harvests more consistently than with the "set it and forget it" approach.

Another great technique for starting outdoor mushroom patches is the "raft-style" log bed. A mature log raft achieves an impressive biomass, and will produce for a long time.

To do this, start by inoculating logs according to the process outlined in the previous section. Then prepare your bed according to the instructions above, but dig a little deeper into the ground. Lay down your first layers of cardboard and spawn, then nestle the inoculated logs side-by-side like a raft. Cover them completely with spawn and wood chips, and continue as usual to make your thick, woody lasagna.

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